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ROYAL BOTANIC GARDENS, KEW.

BULLETIN

OF

MISCELLANEOUS INFORMATION.

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XVI.—SILVER LEAF DISEASE.*

Stereum purpureum.

J. BINTNER.

(With Plate.)

I.—INTRODUCTION.

"Silver leaf" is notorious not only for the serious damage which it causes to fruit trees but also for the controversies concerning the nature of the disease.

The first observations were made by Prillieux (1) 1885 in France, and published under the title of "Le Plomb des arbres fruitiers." He considered the leaden colour of the leaves to be the result of the presence of large air spaces between the epidermal and palisade cells; he also noticed larger epidermal cells in the infected leaves than in the normal leaves. In 1886 Sorauer (2) referred to the "Milchglanz" of fruit trees, and again Aderhold (3) in 1894, mentioned it as occurring in Germany. Both these authors considered "Silver leaf" of fruit trees as of non-parasitic character. This theory however became very improbable on the discovery, made in England by Percival (4), who in 1901 applied the name "Silver leaf" to the disease, that fungal hyphae existed in the wood of silvered plum-trees. Successful inoculation experiments by Percival, who proved that silvering could be caused by the fungus *Stereum purpureum*, did not however convince all his contemporaries. Massee (5), for instance, still attributed the disease to some physiological disturbance. Delacroix (6) erroneously states that Percival had described *Stereum hirsutum* as the cause of silvering, and even adds: "Malgré l'affirmation de cet auteur (Percival), nous ne pouvons, jusqu'à plus ample informé, admettre de telles conclusions." Blackmore (7) in commenting on this disease in his report on New Zealand diseases, states that "Silverblight certainly is becoming very prevalent in a number of orchards in North Otago and elsewhere. Often where fruit trees are making succulent growth it spreads rapidly, killing trees within

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two years. For a long time I have noticed that with fruit trees which have been killed by Silverblight, there occasionally appears on the stem or branches some time after the death of the tree the fructification of a fungus; but so much has been said in reference to Silverblight being due to bacteria that I do not think the roundish disc-like fungus growths are connected with Silver leaf disease." Later he adds: "I however forwarded specimens to England to a friend, who identifies them as the same fungus which is considered by Professor Percival and others to be the cause of Silver leaf disease of fruit trees in the United Kingdom." The above quotations clearly indicate the scepticism of a number of workers with regard to Percival's discovery. The latter's views were, however, confirmed by Pickering (8) at Woburn during 1906-1909, as the result of a large number of successful inoculations of various fruit trees and a few other trees and shrubs with *Stereum purpureum*. Similar results, with equal success, were obtained in the detailed work at Cambridge and Merton of Brooks (9). Güssow (10) observed Silver leaf in Canada and repeated with success similar inoculation experiments. The latest contributions on Silver leaf by Smolak (11) leave that author still doubtful as to *S. purpureum* being the sole cause of Silver leaf. He discovered bacteria in silvered leaves, but he considered them of secondary nature.

In view of the wide distribution of this insidious disease, throughout the continent of Europe, from England to the Balkans, and in America, where, according to Güssow (12) it is prevalent in Canada, from St. John's, Newfoundland to Vancouver Island, and also in Australia and New Zealand, it is plain that Silver leaf is very likely to hamper considerably the fruit growing industry throughout the world unless prompt action is taken to cope with the disease. Unfortunately in England the best varieties of cultivated plums are most susceptible to Silver leaf, as can be judged from the plum orchards in Surrey, Middlesex, Kent, and Worcestershire, where in certain plantations 60-95 per cent. of the plum trees of "Victoria" and "Czar" varieties have been so severely attacked that wholesale grubbing out of these trees has had to be resorted to.

The following gives a list of plants known to be affected by Silver leaf:—

Those marked with * have been observed by the author, those marked *† are new records.

Rosaceae.

*†1. *Neviusia alabamensis*, A. Gray.

*2. *Spiraea japonica* var. *glabrata*, Lange.

3. *Philadelphus* sp.

4. *Exochorda* sp.

5. *Pyrus Malus*—cultivated varieties of Apples.

*Lord Grosvenor.	Newton Wonder.
*Bramley's Seedling.	Lord Suffield.

P. prunifolia.

P. triloba, Lindley. var. *flore pleno*.

*6. *Prunus Amygdalus*, Stokes, and cultivated varieties of Almonds.
P. Armeniaca, Linn. and cultivated varieties of Apricots.
**P. Avium*, Linn., Gean.
**P. Cerasus*, Linn. and cultivated varieties of cherries.
**P. communis*, Hudson. Wild Plum.
†*P. japonica*, Thunberg.
**P. lusitanica*, Linn. Portugal Laurel.
**P. spinosa*, Linn. Sloe.
*†*P. acida*, Ehrhart. var. *flore pleno*.

7. Cultivated varieties of Plums:—

Pond's Seedling.	*Victoria.
Monarch.	*Czar.
Gisborn.	*Belgian Purple.
Several gages.	*Damsons.

8. Stocks used for grafting:—
*†The Brompton.
*†Myrobella (*Prunus myrobolanus*).
*†Common Plum stock var.

Saxifragaceae.
*†*Ribes cereum*, Douglas, and cultivated varieties of Gooseberries and Currants.

Leguminoseae.
**Laburnum vulgare*, Presl.
*†*L. alpinum*, Presl.

Oleaceae.
Syringa sp.

Sapindaceae.
Aesculus Hippocastanum, Linn.
*†*A. carnea*, Hayne. var. Briotii.

Ericaceae.
*†*Pernettya mucronata*, Gaudich.

†Noted by Mr. F. J. Chittenden at the R.H.S. Gardens, Wisley.

All material used for examination, as described in this paper, was secured from naturally infected "silvered" plants growing in the open, not from artificially inoculated plants, nor from branches which had been killed by the fungus. The plants were marked in the field during the summer of 1918, and from October onwards, and material was taken, as required, to the laboratory. Unfortunately the leaves could not in all cases be examined, as the majority of plants were of a deciduous character, so that the leaves had dropped before the microscopic details could be studied.

The tracing of the fungus in diseased tissues is by no means an easy task, owing to the fact that the hyphae are extremely fine. The following method was adopted:—The material was cut into cubes of about 1 cm. and steeped for 6-8 days, or even a fortnight according to the nature of the material, in a saturated solution of picric acid in 50 per cent. alcohol. For sections,

soaking for 4-6 hours is sufficient. The excess of picric acid is washed off and the section stained with concentrated Delafield haematoxylin (ripe solution) for at least 4-6 hours, or preferably overnight, according to the nature of the material. Picric acid stains lignified tissues a yellow-citron, and haematoxylin imparts a blue colour to the hyphae.

In the following account a description is given of the diseased condition as found in the following plants, in which the hyphae of *Stereum purpureum* have been observed.

II.—Specific Cases.

(1) **Victoria Plum.**—The Plum orchards in the Brentford and Heston district of Middlesex suffered severely from Silver leaf during 1918; eighty to ninety per cent. of the plum trees (of ages from 5-30 years), chiefly the varieties "Victoria" and "Czar," were so severely affected that they had to be cut down during late summer and early autumn. Owing to a scarcity of labour the sawn-off branches and tree-stumps were not removed from the plantations. The first fructifications of *S. purpureum* developed during the last week of September on this dead wood and also on silvered trees still standing. Undoubtedly diseased wood in the plantations will endanger plum and other trees in the neighbourhood. The plum trees met with in the orchards of this locality were mainly grafted on the "Brompton" and "common plum" stocks. Generally where suckers grew up from the stocks of silvered plants, they showed silvering relatively to the same extent as the scion, and this irrespective of the age of the plum tree. In a few cases, however, I noticed normal suckers of "Brompton" and "common plum" stock coming up from silvered trees. Healthy suckers were most common on partially silvered plants, that is, where only *localised* branches of a tree were attacked, mainly where only the upper set of branches was affected by the disease. I also noticed on a few completely silvered trees healthy suckers of the above varieties arising from the stocks. Silvered suckers, one year old, to the number of 150, were dug up and their roots examined; 10 of these were taken to the laboratory, and 140* were examined in the field. Of the latter 26 appeared normal to the naked eye in roots and stem, whereas the remaining 116 revealed discoloration of the tissues in cross section of roots and at the base of the stem. A few two-year-old suckers were also examined and the discoloration was still more obvious. The discoloration in the 10 suckers mentioned above could easily be traced up the suckers for two-thirds to three-quarters of their length. The discoloration usually consisted of 2-4 reddish brown streaks which sometimes ran parallel, but frequently followed a winding or twisting path in the stem. The streaks were confined to the outermost xylem.

The following table indicates the height reached by the discoloration and by the hyphae in five one-year-old suckers.

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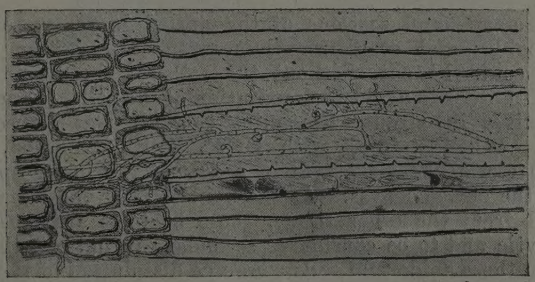
* These 140 suckers have been planted in the experimental plot of the Royal Horticultural Society Gardens, Wisley.

Number of Sucker.	1.	2.	3.	4.	5.
	cm.	cm.	cm.	cm.	cm.
Total length of sucker from its point of origin	110	140	102	80	95
Height reached by the discoloration visible to the naked eye	65	83	52	51	60
Height reached by the hyphae	62	79	51	47	58

For some little distance above the point where the brown streaks cease to be visible to the naked eye the microscope shows scattered patches of brownish material in the vessels.

In completely silvered trees and in those where the lowest set of branches (the first branches developed on the stem) were infected the discoloration was continuous from the twigs into the branches, down the main stem, through the point of union between scion and stock, into the superficial roots of the latter, and from these roots it could be traced again upwards into the stem of the sucker.

In agreement with previous workers, I found that no trace of hyphae could be observed in the leaves or petioles of silvered plum trees and suckers. Hand-sections made from the discolored zone of the root stock, branches and twigs, and of the roots and stems of suckers, disclosed the exceedingly minute hyphae which, when stained, could be seen invading the wood vessels in all directions. In suckers the fine hyphae extend from the cambial region inwards into the wood parenchyma; they sometimes keep a straight course in the discoloured vessels, but occasionally branch when a few filaments may trespass upon the yellowish-brown deposit of the cell-cavity. The hyphae do not seem to enter a vessel at any particular spot, since they can be seen passing across the lignified walls in their thickest parts, and they develop luxuriantly in the lumen of the vessels. They can also be traced in the intercellular spaces, as in Text fig. 1,



Text fig. 1.—Longitudinal section through the wood of a silvered plum sucker, Brompton stock.

in fact, wherever there is room for development. In the living tissue no hyphae were found outside the cambial region; but in

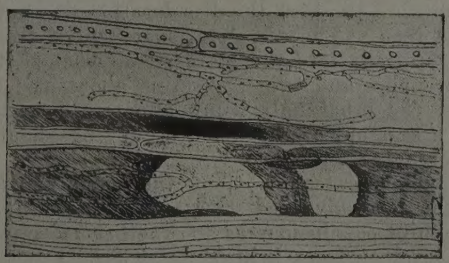
branches or superficial roots which have been killed by the fungus, and where there is an indication of the fructifications beginning to pierce the bark, the hyphae are naturally present in practically all the tissues. The hyphae are septate, and clamp connections frequently occur (see Fig. 1). The brown material on which the discoloration depends is found mainly in the xylem vessels, but some cavities and the walls of the medullary ray cells are also stained, as well as certain cambium cells.

(2) **Prunus lusitanica.**—Among the evergreen members of the Pruneae, this is the only species which up to the present has been found to suffer from Silver leaf disease. The material selected for the present investigations was secured from the Prunus collection in the Royal Botanic Gardens, Kew. On individual plants several branches showed silvering, the youngest leaves of the current year's growth seeming to be most severely attacked. The curling over of these leaves rendered them very noticeable at a distance. The upper and lower epidermis were found in many instances to be loosened and even hanging in shreds as a result of contact with other branches and leaves (see Plate). The previous year's leaves and also those of early spring growth, though severely affected, did not display any curling or blistering. The upper and lower epidermis of such diseased leaves could be peeled off with a penknife with comparative ease. On cutting off branches from one to five years old a conspicuous discoloration was to be observed in the region of the outer xylem; only in branches five to ten years old, however, did the discoloration extend into the older xylem. A branch which had its origin below ground was cut off immediately above the soil level; three weeks later, towards the end of September, fructifications of *S. purpureum* developed on the cut surface of the part of the branch still attached to the plant, the fructifications taking their origin from the region of the young wood. Another 8 in. was then cut off and in turn fructifications were produced 23 days later on the surface so exposed.

Satisfactory hand sections of the curled leaves were clearly unobtainable; and even from less infected leaves no suitable sections could be cut, without the cells of the tissue falling apart. In order to avoid the separation of the cells, the material, after fixing in strong Flemming's fluid, was imbedded in paraffin. When staining with E. F. Smith's method, I perceived bacteria-like structures in a few of the lower epidermal cells of the curled leaves. As the epidermis of these leaves was detached from the other tissue, these bacteria are most likely saprophytic and to be considered secondary in nature; they were absent in those epidermal cells where no dissolution of the middle lamella had taken place. No hyphae could be seen in any part of the leaves or petioles either in cross or longitudinal sections. In one-year-old twigs a few threads occasionally passed from the cambial layer into the bast parenchyma, causing discoloration of the latter, but the hyphae were most prevalent in the primary wood vessels, which in turn showed distinct discoloration.

(3) **Prunus triloba** var. **flore pleno.**—In 1916 localised silvering appeared on a few individual plants of this variety which were growing in a bed at Kew; but in the late season of 1918 the disease had spread to many other plants in the same bed, a few of which were completely silvered. In December several silvered branches were cut off and examined. When removing the bark with a pocket-knife the peculiar discoloured streaks were noticeable again, similar to those mentioned under "Victoria Plum." In the case of one three-year-old branch these discoloured streaks were followed upwards into the terminal bud of the current year's growth. A very characteristic feature in the silvered branches of *Prunus triloba* is that the bark can be stripped off with comparative ease. On two shrubs *Stereum purpureum* fructifications were developing.

Owing to the season being so far advanced, no leaves could be examined. When cutting hand sections of the diseased stem, the same difficulty in obtaining intact slices was experienced as with silvered leaves of "Victoria Plum." Abnormal air spaces occurred in the bast of affected twigs. The cambial cells and the cells of the adhering tissues fell apart from the xylem. Isolated, single phloem-parenchyma cells were found floating free on the slide; thus the separation of these cells resembles the separation of the mesophyll cells of the leaves, resulting apparently from the same cause, namely, the dissolution of the middle lamella. In the three-year-old branch mentioned above, the hyphae were traced to within a centimetre of the terminal bud. Text Fig 2 indicates hyphae in the xylem vessel.



Text fig. 2.—Longitudinal section of *Prunus triloba* var. *flore pleno*, showing hyphae in the xylem vessels bordering the cambium.

The severe pruning to which this variety of *Prunus* is annually subjected immediately after flowering undoubtedly increases the opportunities for the entrance of the fungus.

(4) **Apple Trees.**—In October, 1918, Messrs. White & Sons, Paddock Wood, Kent, forwarded to me twigs and leaves of "Grenadier" and "Lord Grosvenor" apple trees which were attacked with Silver leaf. It was practically impossible to cut entire hand sections of the leaves of "Lord Grosvenor" without the tissue falling apart, owing to the fact that they exhibited a phenomenon similar to that of the leaves of plums. The

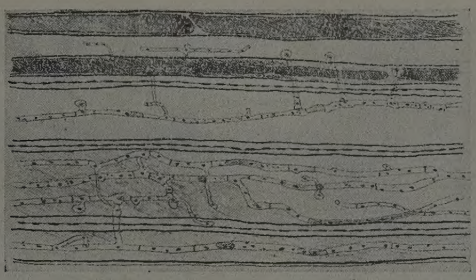
upper epidermal cells separated as a layer from the palisade cells; the palisade cells fell apart and were found to be filled with a brownish coloured material which gave a silver-brown appearence to the leaves. No hyphae were to be obtained in the leaves or petiole, nor could they be traced in any of the twigs which measured less than 8 in. in length, although these twigs showed on cutting conspicuous discoloration from the basal end upwards.

The variety "Grenadier" was only slightly attacked, and instead of a shiny grey brownish tint on the upper surface, as in "Lord Grosvenor," the leaves were a dark leaden colour. There was no separation or falling apart of the epidermal or palisade cells. In hand sections, the leaves seemed almost normal, with the exception of a reduction in chloroplasts, and there was no sign of discoloration in the twigs. Although I was unable to examine the trees in the field, it is presumable from the information received, together with the above observations, that the apparent silvering in the variety "Grenadier" cannot be attributed to the action of a foreign organism; the lead colour is probably due to some physiological weakness of the tree.

Early in January, 1919, I observed a tree, stated to be "Bramley's Seedling," growing in a cottage garden at New Cross, London, which produced numerous confluent masses of fructifications of *Stereum purpureum* on a side-branch towards the base of the stem; the branches developing immediately above this on the same side of the tree produced also tiny scattered tufts of the fungus. On cutting off the lowest branch near the stem, the characteristic browning could be seen at the amputated ends, and on removal of the bark the discoloration was found to extend down to the roots. The discoloration extended from the superficial roots upwards into the main stem, whence it passed into the main branches and twigs, affecting about half of the crown of the tree, the other half being apparently normal. In the main stem a segment of the wood, occupying about one quarter of the whole area in transverse section, showed marked discoloration which extended from the cambium to the pith. Owing to the very advanced state of the disease it was difficult to draw definite conclusions as to whether infection took place below soil level or from injured branches. Curiously enough, the diseased part of the tree had suffered severely during the last few years from "American Blight" (*Eriosoma lanigera*); the damage caused by these insects was very marked on the branches and the twigs, as shown by the presence of intumescences and abnormal growth. It is highly probable that the punctures and the subsequent wounds produced by this insect facilitated the penetration of *S. purpureum*.

Well-developed mycelium in the twigs, branches and main stem was to be observed in longitudinal sections of the discoloured wood. The fine threads could be easily traced from the branches into the fruiting spurs, but with greater difficulty in the one-year-old twigs; the hyphae branched frequently and were of irregular thickness (see Text Fig. 3). They were found more abundantly in the external layers of xylem than in the inner;

and they were particularly abundant in the scattered vessels or tracheids which contained no brown material. In the medullary rays the "browning" of the cells was very irregular, some of



Text fig. 3.—Hyphae of *Stereum* in the wood vessels of apple, "Bramley's Seedling."

the cells containing hyphae having brown walls and contents, while others, which contained hyphae, were otherwise unaltered.

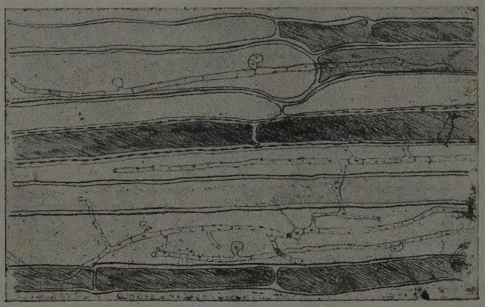
(5) **Spiraea japonica** var. **glabrata** (**sp. glabrata**).—In October, 1918, I observed one silvered shoot of the current year's growth in one plant amongst 33 others growing at the Royal Botanic Gardens, Kew. This Spiraea belongs to the section which is pruned to about 4 to 6 inches above the ground. The first two buds lying below the point of pruning were dead, and the silvered shoot had developed from the next bud at a point about 5 cm. below the cut surface. On splitting the branch which bore the silvered shoot, slight discoloration of the wood could be traced from a point about 3 cm. below the silvered shoot to its point of origin, and then up that shoot to a height of 4 cm.

The leaves could not be examined microscopically. In the roots and in other parts of the shoot no trace of hyphae was to be seen except in the discoloured tissues. The hyphae were followed downwards for 5 cm. from the point of pruning, and for about 3·5 cm. up the silvered shoot. The discoloration was everywhere more extensive than the distribution of the hyphae; the latter occurred at the periphery of the wood, whence they could be traced inwards, branching in all directions and occasionally developing clamp connections (see Text Fig. 4).

From the above observations, it is evident, in this particular instance, where only one shoot out of many on the same bush and amongst other plants in the same bed became silvered, that the fungus had penetrated through a wound caused by pruning.

(6) **Neviusia alabamensis.**—During the late summer of 1918, a plant of this species growing at Kew, was noticed to be silvered. It was not examined until November, when a silvered plant was dug up, with its roots, for laboratory investigations. The root stock had suffered injury and was distinctly discoloured; a part

of it had already been killed. On splitting the shoot so as to expose the pith, it was noticed that the discoloration was found throughout the wood but it was most marked towards the pith.



Text fig. 4.—Longitudinal section of *Spiraea japonica* var. *glabrata*, showing hyphae in the wood.

The discoloration could be traced upwards to a point 90 cm. above the root stock, but the last 20 cm. of the shoot displayed no discoloration. Three other silvered shoots were cut off above ground, measuring from their point of last year's pruning, 140, 135, and 150 cms. respectively; curiously enough on splitting these shoots the discoloration was found to be absent from the base upwards to a height of 40, 45, and 63 cms. respectively; the browning then gradually increased in an upward direction towards last year's point of pruning. The absence of discoloration at the base of these three shoots suggests that the fungus had entered through the wounds caused by pruning.

The nature of the discoloration of infected material varies within the tissues and according to the host. In the roots of *Neviusia* the discoloured cells assume various colours, from a purplish red to magenta, seldom a reddish brown (see Text Fig. 5). In the stem, the purple and magenta colour are replaced by a reddish pink, passing over to a dark brown. Abundant hyphae were present in the wood generally, but they were predominant in the xylem elements bordering the pith. (Text Fig. 6.) This is probably owing to the fact that there is greater aeration in the pith region. No hyphae were noticed beyond the discoloration, which proves that the fungus has penetrated in the one case through the injured root stock, and in the other three cases as a result of pruning.

(7) **Ribes cereum.**—While examining the bed of Portugal Laurel in Kew Gardens, already referred to, my attention was drawn to a plant of *Ribes cereum* growing about 26 ft. distant. On a single shrub four branches of the current year's growth exhibited silvering; one of these, a sucker, was taken to the laboratory. The remaining three shoots had developed at different heights from the ground; they were cut up into suitable

lengths for propagation and inserted, in order to see to what extent silvering may be transmitted by vegetative propagation.*

The discoloration in the wood was very slight and could only be seen with a pocket lens; it was traced for a distance of 18 cms. up the silvered sucker.

Text fig. 5.—Longitudinal section of root of *Neviusia alabamensis.*

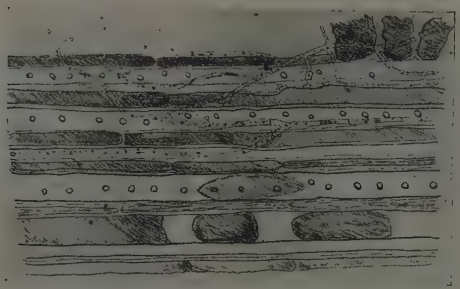
Text fig. 6.—Longitudinal section of a shoot of *Neviusia alabamensis.*

The hyphae were followed to within 2 cm. of the upper limit of the discoloured wood. In the silvered branches the inner wood elements are stained pink, passing over to bluish magenta towards the cambial region, whereas the cavities of the phloem and medullary rays cells are filled with a dark brown mass. Very few hyphae were seen in the central wood elements, but abundant threads were present in the elements bordering the cambial region (see Text Fig. 7). It was difficult to cut entire hand sections, as the xylem invariably separated from the bast; the cambial cells showed localised disorganisation as a result of the invading hyphae; the bast parenchyma also was somewhat affected and easily broke up, but no hyphae were observed in it.

The leaves were not examined and no fructifications of *Stereum purpureum* were noted anywhere on this partially silvered plant, but the characters of the hyphae were identical with those of other hosts, and those of mycelium grown in artificial cultures. Whether shoot as well as root infection took place in this plant cannot definitely be stated, but since browning could be traced from the root-stock into the lower part of the sucker only, it is certain that in this case the fungus gained entry through the injured root-stock.

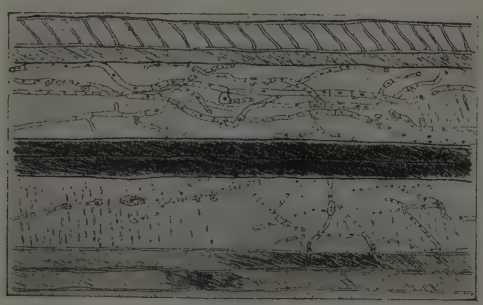
* 15 cuttings were inserted in a cold frame in the Royal Botanic Gardens, Kew, all of which have produced silvered shoots.

(8) **Laburnum vulgare** and **L. alpinum.**—The common Laburnum is mentioned by Güssow (12), Pickering (8), and Brooks (9), as having suffered from Silver leaf disease. Apart



Text fig. 7.—Longitudinal section through the wood of a shoot of *Ribes cereum.*

from the genus *Prunus* I have noticed no more extensive destruction on any other ornamental tree or shrub as a result of *Stereum purpureum* than on *Laburnum alpinum*. Judging from the damage caused during 1918 in the surburban district of London, where, in certain localities, up to 25 per cent. of the trees developed *S. purpureum* fructifications during autumn and winter, it is highly probable that unless drastic measures are taken the cultivation of *Laburnum alpinum* will become impossible. So far I have only met one case of a living tree of *Laburnum vulgare* bearing *S. purpureum* fructifications. A living side-branch of *L. vulgare* about four years old showed discoloration in the wood, a discoloration occupying about 100° of the circumference, but the extent gradually diminished upwards in the four and three year old wood. On reaching the two-year-old branches it was confined to the cambial region and to about one-third of the circumference, whereas in the one-year-



Text fig. 8.—Radial longitudinal section of the xylem vessels of *Laburnum vulgare* showing deep discoloration and abundant hyphae.

old twigs (current year's growth) it was reduced to a few continuous streaks.

Abundant hyphae were found growing in all directions in the wood elements (see Text Fig. 8), from the cambial region inwards. The hyphae present in the lumen of the vessels were in every respect identical with those observed in other hosts, already referred to, and similar to those grown in artificial cultures of *Stereum purpureum*.

There was no opportunity of examining the roots of *Laburnum vulgare*, and it is unknown if root infection took place. The fact that the upper set of branches of one half of the tree was killed by the fungus, whereas the lowest branches were apparently normal, indicates that the fungus penetrated through wounds in consequence of pruning, or through the abraded surfaces which frequently occur in the crown of the tree.

III.—Modes of Infection.

According to Percival (4), Güssow (12), Pickering (8), Brooks (9), the fungus *Stereum purpureum* is a wound parasite. In order to confirm this view several inoculation experiments were carried out in the laboratory. Pieces of mycelium, fructifications, and spores were placed on uninjured leaves of *Prunus lusitanica* in Petri dishes. Although the conditions for development of the fungus were most favourable, yet no invasion into the tissue could be observed. If, however, spores, pieces of fructifications and mycelium are laid on leaves which have been scratched with a needle or from which the epidermis has been removed, the penetration of the hyphae into the host soon begins, followed by partial disorganisation of the cells of the leaf. It is clear that the fungus if it can once gain entry can develop in the leaf, and it is hoped to carry out further experiments on this point.

Several plants of *Prunus lusitanica* were inoculated by placing pieces of mycelium of *S. purpureum* beneath the bark of stem, branches and roots. Within three weeks, discoloration of the cambial region of the wood appeared on both sides of the point of inoculation. In agreement with Brooks, I observed the rapid growth of the hyphae in an upward direction and a very slow progression down the shoot. Precisely the same process results from the insertion of pieces of fructifications or pieces of mycelium in the roots. In the control experiments no effect at all was obtained.

Stem and Branch Infection.—From the actual observations in the laboratory and in the field it would be premature to state at what particular time of the year infection takes place, since it is not yet known how long the spores retain their vitality. The following observation shows that they are capable of immediate germination. An old silvered branch of "Victoria Plum" was taken to the laboratory in October, and *S. purpureum* fructifications developed upon it within eight days from the day of amputation. Basidiospores taken from these fructifications germinated within 24 hours in hanging-drop cultures. Spores are undoubtedly blown about by the wind and possibly alight on

open wounds, where, under favourable atmospheric conditions, they germinate and penetrate the host.

Localised silvering of a branch or twig in any shrub or tree originates from local infection through unprotected wounds of branches and twigs. The spreading to other branches follows according to the progressive development of the hyphae inside the tissue; and since the hyphae grow more rapidly in an upward than in a downward direction, the silvering of the uppermost set of branches is explained, whereas the lower placed branches of the same tree may remain healthy for one or two seasons. The few cases known where healthy suckers come up from silvered trees are due to the fact that the hyphae have not yet passed to the root-stock or that the stock used for grafting may be less susceptible or even immune.

Root infection.—Many silvered suckers have been observed developing from normal plum-trees. It is common knowledge that Silver leaf on "Victoria" and other varieties of plums is more prevalent in plantations where the soil is cultivated for catch crops, than it is on grass land. This is probably due to the fact that while cultivating large plantations with a plough, or even a spade, it is difficult to avoid injury to superficial roots. Certain stocks, such as "Brompton" and "Common Plum," when used for grafting, send up every year numerous suckers, the removal of which causes additional injury. Other cases were noticed, where the lowest set of branches from the main stem showed silvering, while the upper branches were normal. No abrasion or jagged surfaces could be seen on any of the diseased branches. The removal of the lowest set of these silvered branches would by no means save the tree, since the discoloration extends to the main stem. A few cases were observed where silvered suckers arose from a plant, the upper parts of which were entirely normal. This strongly indicates root infection, probably through injury to superficial roots.

IV.—Preliminary Preventive Measures for True Silver Leaf.

Owing to the increase of Silver leaf the fruit-growing industry is seriously threatened, particularly with regard to our choice varieties of plums, *e.g.*, "Victoria" and "Czar," and soft cooking varieties of apples (already subjected to many other pests), "Lord Suffield," "Bramley's Seedling," "Lord Grosvenor," "Emperor Alexander," which are likely to go out of cultivation. The spreading of the disease to many ornamental trees and shrubs is also causing considerable alarm to growers. Prompt and drastic measures should therefore be taken to stamp it out.

In controlling plant disease one may adopt either curative or preventive measures. Unfortunately up to the present no practical *curative* measures with regard to Silver leaf are available. As a preventive measure all that one can recommend is good cultivation, using that expression in its widest sense.

Careless pruning, unsatisfactory drainage and a deficiency of lime are especially to be avoided. The application of artificial fertilizers, particularly those of highly nitrogenous character, induces "soft" growth, with its greater liability to injury by frost and by insects. It is evident from the observations here put forward that those stone-fruit trees and other trees and shrubs annually subjected to pruning are much more likely to fall victims to Silver leaf than those which are not so treated. Indiscriminate pruning, and the cutting off of old branches for fire-wood, as was done in war-time, pave the way for the entrance of the fungus if the cut surfaces are not immediately treated.

The following primary preventive measures are recommended:—

1. The destruction of *Stereum purpureum* wherever it occurs, whether it is growing as a parasite or as a saprophyte.

2. If localised silvering in the upper set of branches of a tree is noticed, the silvered branches should be cut off without delay *below* the limit of discoloration of the wood. Many trees have been saved from total destruction where this method has been followed. Should, however, the lowest branches of a tree be affected, there is little hope of recovery, since the fungus is then present in the main stem. Such trees should be grubbed up before the fructifications develop, usually about September.

3. Whenever a branch is amputated, it is essential that the branch should be cut off as near as possible to the main stem or to the point of origin in order to encourage more rapid "callusing." A clean cut with a knife should follow the saw, especially where a jagged surface has been left. When pruning branches of the hosts mentioned on pp. 242, 243 of this paper, the cut surface should be protected immediately, thus preventing the spores of the fungus, which are blown about by the wind, from penetrating the host. Stockholm tar or its equivalent being one of the cheapest substances for protecting the wounded surface can be used for commercial purposes, whereas on a small scale, grafting-wax may be employed.

4. Removal of all dead and diseased wood from the plantation, since the fungus in the wood will soon develop fructifications, the spores from which are a great danger to the trees in the vicinity. Diseased branches should not be used for fencing, as this involves the same danger as when left in piles in the orchards. Storing of the wood under such dry conditions as prevent the development of the fungus should be aimed at. An alternative method, which may be adopted in large plantations, is the conversion of such cut off branches into charcoal in the field.

5. In plantations where the plough is used for catch crops, it is difficult to prevent injury to superficial roots, but additional injury by the spade may be minimised by a careful use of that implement, and by the pulling up of suckers.

6. Varieties of plums grown on their own roots produce only a few or scarcely any suckers, and hence the planting of such varieties is advisable whenever circumstances permit.

7. The planting of resistent or less susceptible varieties of

plum, such as "Yellow Pershore Plum" (sometimes called "Yellow Egg Plum") and "Early Rivers," is highly to be recommended.

8. The soft cooking varieties of Apples are more susceptible to Silver leaf than others, the latter should therefore preferably be planted.

9. Certain stocks, such as the "Brompton" and "Common Plum," are highly susceptible to this disease, whereas the "Yellow Pershore" is more or less resistent, and, in addition, possesses other valuable qualities.

10. Pruning of ornamental trees and shrubs known to be affected by this malady should be discontinued, unless the cut surfaces can be protected immediately after the operation.

11. When replanting infected orchards precautions should be taken to avoid the varieties of trees mentioned on page 242, since these varieties have proved susceptible to "true Silver leaf." An alternative to this is the interplanting in Plum orchards of Pear trees, or Cob-nuts and Filberts.

General Discussion.

The results described in the present contribution clearly support the view that *Stereum purpureum* is the main cause of Silver leaf. Cases of Silver leaf, however, are here described in which no trace of the fungus could be detected in any part of the plant.

It is suggested that silvering caused by *Stereum purpureum* should be called "True Silver leaf," and the term "False Silver leaf" be applied to those cases where the fungus is absent, the cause being apparently some physiological weakness.

In July, 1918, a plant of *Camellia Sasanqua* var. was observed in a pot in the Temperate House, Kew Gardens, which exhibited marked silvering of the leaves. The roots, branches, and twigs of this plant were examined, but no trace of hyphae were found. Local discoloration in the cells of the various tissues was observed here and there, but a continuous streak was never perceptible. Hand and microtome sections, both longitudinal and transverse, of petioles and leaves, failed to reveal any fungal threads. In hand sections no separation of the tissues occurred, indicating that there had been no dissolution of the middle lamella. In comparison with normal leaves, a waxy deposit of the colour of white lead is secreted by the affected leaves, and this gives a silvery appearance when the leaves are seen from a distance. There was also a reduction of chloroplasts in these leaves as compared with the healthy ones.

"False Silver leaf" is also to be found on a few varieties of Apples, the variety "Grenadier," already mentioned, and "Bramley's Seedling." It has also been observed on *Koelreuteria paniculata*, Saxm., on cultivated varieties of Cherries, Peaches and Plums. False Silver leaf is probably due to some physiological disturbance of the plants, possibly induced by unsuitable treatment. Plants of *Koelreuteria* which showed this false Silver leaf during one or two seasons, were observed to regain their normal colour under improved cultural treatment.

Silvering is more common, according to my observations, where the drainage is bad and where there is a deficiency of lime in the soil. If the trees are top-grafted on an unsuitable stock, the chances of the occurence of false Silver leaf appear to be increased.

The following table indicates the distinction between true and false Silver leaf:—

True Silver Leaf. (Cause.—*Stereum purpureum.*)	False Silver Leaf. (Cause.—Physiological Weakness?)
1. Easy separation of the tissues of the leaf, resulting from the dissolution of the middle lamella; usually no reduction in the number of chloroplasts.	1. No separation of the tissues of the leaf; the chlorophyll is reduced in amount.
2. Discoloration present in the xylem or other tissues of the branches, stem and roots, appearing as continuous streaks, very seldom in scattered patches.	2. No regular discoloration in the stem, but it may occur as small localised areas, never in continuous streaks.
3. Branches placed in water for 48 hours discolour the water after 48 hours. In those cases where normal branches discolour the water, the coloration is different in the case of diseased branches.	3. Branches placed in water for 48 hours do not discclour the water as compared with normal branches.
4. Fungal hyphae always present in the stem or root, but so far not discovered in the leaves.	4. No fungal hyphae in any tissue of the plant.

It should be noted that it does not necessarily follow that in every part of a true silvered plant all four distinguishing characters would be met with. When dealing with plants which in normal conditions discolour water, care must be exercised that branches or twigs of equal size are taken and the capacity of the vessel considered.

As far as published evidence goes, no mention has been made of "False Silver leaf" by any writer on the subject. Brooks, however, observed a plant of *Lamium album* exhibiting Silver leaf with a shrivelled epidermis, which could easily be separated from the mesophyll cells, but he concluded that the silvering in this case could not be attributed to *Stereum purpureum*. Brooks also draws attention in his second paper to the confusion of Silver leaf with Chlorosis when dealing with applications of iron compounds to restore normal growth. It is therefore very difficult to comment on the work of those who hold the physiological theory of the cause of Silver leaf, but according to the work of Prilleux (1), Sorauer (2), Alderhold (3), and Massee (5), it is obvious from their descriptions that they were dealing with *True* Silver leaf, although these writers invariably interpreted the disease as of non-parasitic nature. A considerable amount of material is required for successful investigation, particularly fair-sized twigs and branches, since the hyphae only in extreme cases approach the terminal bud of the current year's growth.

The fact that no hyphae are to be found in the leaves of plants suffering from True Silver leaf has no doubt led these authors to the non-pathogenic theory of the disease. At that time also the fungus *Stereum purpureum* was considered a saprophyte, and it is apparently only during recent years that its virulence as a parasite has increased and has spread to plants belonging to various natural orders. In the case of *Neviusia alabamensis* and *Spiraea japonica* var. *glabrata*, described here, the hyphae would have certainly been overlooked, if the examination had been confined to the apical shoots.

In addition to the literature on Silver leaf mentioned in this paper I have been unable to find any evidence as to bacteria being the cause of Silver leaf, as referred to by Blackmore (7), in his report. It is obvious that soil and atmospheric conditions or other environmental factors of a greenhouse are capable of causing physiological injury to the plant, but up to the present there is no evidence indicating parasitic bacteria as the cause of either *True* or *False* Silver leaf.

It is interesting to note that the partial disorganisation of a tissue, as a result of the dissolution of the middle lamella, in which fungal hyphae are not present—which is normal to the leaves of silvered plants—is also found in the silvered *twigs* of *Prunus triloba*, var. *flore pleno*. There the bast shows partial disorganisation, although the hyphae are confined to the cambial region.

Since enzymes are apparently colloidal substances which would diffuse with difficulty through cell-walls; the most satisfactory explanation of the changes in the leaf, seems to be the one suggested to me by Professor V. H. Blackman, that some diffusible poisonous substance is produced during the metabolic processes of the fungus or of the invaded cells of the host; this substance is then conveyed to the leaves by the water conducting channels, where it causes a change in the activity of the enzymes capable of acting on the middle lamella of the wall. A similar reaction apparently takes place in the bast of *Prunus triloba* var. *flore pleno*.

In the experiments already described where pieces of mycelium, or fructifications or spores, were placed on injured leaves of *Prunus lusitanica* in petri dishes, the hyphae were found to have penetrated the leaves in about 12 days, without, however, causing a falling asunder of the tissues. The dissolution of the middle lamella therefore does not seem to be due to direct action of the fungus, at least in its early stages, but rather to the result of the interaction of the metabolisms of the fungus and bast cells of the twig. Whether infection can also take place in nature in injured leaves is yet unknown.

The appearance of the discoloration varies with the different host plants. In all the cases examined, the discoloration of the host tissue extended beyond the limit of the hyphae. Brooks' observations on the discoloured wood of plum trees were confirmed by placing pieces of the fructifications or ordinary mycelium from artificial cultures on sterilized blocks of plum wood. In four days a definite discoloration of the wood was to be observed; when

three weeks later the block of wood was examined no hyphae could be found towards the edge of the discoloured area. To avoid confusion between the discoloration produced by the fungus and that resulting from oxidases, the material was steeped in boiling water for ten minutes before being cut into sections.

With regard to the general characteristics of *Stereum purpureum*, it was found that this fungus varies considerably in colour and in external characters. It differs apparently according to whether it has been growing parasitically or purely saprophytically, for the fructifications on *Salix* have distinctly smaller spores than those on Plum and Apple. However, for the present, the fungus must be treated as a single polymorphic species, as only definite evidence afforded by a series of careful investigations would justify the division of the species into distinct forms. *S. purpureum* is found growing as a saprophyte on the dead wood of the following genera: *Betula*, *Corylus*, *Fagus*, *Ulmus*, *Genista*, *Salix*, etc. There can be no question that the fungus was less detrimental in past years, and it is only during the last twenty years that its virulence has gradually increased to such an extent that the disease is now of almost epidemic nature. Whether the purely saprophytic form of *S. purpureum* growing on the hosts mentioned above are able to cause "Silver leaf" remains to be proved,* but it is certain that mycelium or pieces of fructifications from *Betula*, *Genista* and *Salix* when inoculated into Plum and Apple trees will cause discoloration of the wood, indicating that the hyphae have developed in the tissues.

The fungus can apparently only enter a living plant by open wounds, and is capable of attacking a great number of woody species, belonging to various natural orders, infection taking place both through the stems and superficial roots. It is facilitated by pruning, particularly when the wounds are left *unprotected*, and also by any mechanical injury of an exposed part of the tree, or as a result of injury to superficial roots.

With regard to the distribution of mycelium, no hyphae have been detected in the lamina or petiole of leaves in any "silvered" plant, either by the author or any previous workers. In the bast of affected twigs of *Prunus triloba* var. *flore pleno*, abnormal air spaces are to be found, and a dissolution of the middle lamella which leads to a falling asunder of the tissues, similar to that found in the leaves of plums. No hyphae, however, were observed. It is evident therefore that under some circumstances the fungus is able to exert in the stem the same injurious action at a distance which is common in the leaf.

VI.—Summary and Conclusions.

The present investigations lead to the conclusion that there are two types of Silver leaf, namely, (1) *True Silver leaf*, by far

* The inoculation experiments which are in progress at the Royal Horticultural Society Gardens, Wisley, definitely prove that the forms of *S. purpureum* found growing as a pure saprophyte are capable of producing Silver leaf, and with the same virulence upon various host-plants as those of *S. purpureum* growing parasitically.

the most common, and caused by the fungus *Stereum purpureum*, and (2) *False Silver leaf*, which is comparatively rare, and due apparently to the result of some physiological weakness. It is difficult to distinguish the two forms by external examination, as the appearance of the foliage is practically identical. *True Silver leaf* however is characterised by a dark discoloration of the wood when seen in cross-section, and a ready peeling off of the upper epidermis of the leaf.

The principal features of the *True Silver leaf* are as follows: The normal green colour is hidden by the presence of air spaces under the cuticle, which causes a reflection of the light, and brings about the silvery appearance. There is usually no reduction in the number of chloroplasts. As a result of the dissolution of the middle lamella of the cell walls of the leaf, the leaf tissues easily fall apart when the leaf is sectioned. The dissolution of the middle lamella is perhaps brought about by the production of some diffusible poisonous substance during the metabolic process of the fungus and of the invaded cells of the host; this substance is then conveyed to the leaves by the water conducting channels, where it causes a change in the enzymes capable of dissolving the pectic substances of the cell-wall. Affected plants moreover nearly always show continuous streaks of dark brown discoloration in the woody tissues of the stem, branches, twigs or roots, which when examined microscopically, reveal the presence of exceeding fine filaments of *S. purpureum*. Branches suffering from *True Silver leaf*, when placed in water for 48 hours cause the discoloration of the water, the degree of discoloration depending on the severity of the attack.

Initial infection takes place above ground and also immediately below the ground level, and so far as the present investigations are concerned, the fungus can only gain entrance through open wounds. Recent inoculation experiments (the results of which will be published later) confirm the view that injured superficial roots can be infected; the frequency of infection probably depends on the variety of the stock used for grafting. Localised silvering of a branch results from local infection, which has not yet spread to the main stem. Silvered suckers originating from a healthy tree indicate root infection, whereas the occurence of healthy suckers from diseased plants points to crown or stem infection, since the mycelium has not yet reached the root system. The following plants have been examined, all of which suffered from *True Silver leaf*: "Victoria Plum" (and the stocks upon which it is usually grafted, *e.g.*, the "Brompton" and "Common Plum"), *Prunus lusitanica*, *P. triloba* var. *flore pleno*, among Apples the varieties "Lord Grosvenor" and "Bramley's Seedling," *Spiraea japonica* var. *glabrata*, *Neviusia alabamensis*, *Ribes cereum*, *Laburnum alpinum and L. vulgare*. Although fructifications of *S. purpureum* have not been noticed in *Ribes cereum* and *Spiraea japonica* var. *glabrata*, yet the hyphae observed in the tissues were identical with the hyphae of that fungus grown in artificial cultures. In view of the frequency and the disastrous effects of *True Silver leaf*, and its increasing world-wide importance, the author of this paper recommends the ex-

termination of *Stereum purpureum* wherever it occurs. This is further advisable since it is known that the saprophytic forms have the same injurious effect when inoculated into living trees as those found parasitically. Preliminary measures of a preventive nature are described.

False Silver leaf is much less prevalent than *True Silver leaf*. It is easily distinguished by certain microscopic characters. The leaves show a reduction in chloroplasts, which gives them a silver-lead colour from a distance; there is however, no dissolution of the middle lamella, and no falling apart of the cells. No hyphae have been observed in any part of a diseased plant. There are no continuous streaks of discoloration to be observed in the wood, and cut-branches do not discolour the water when placed in it. The former is perhaps the only reliable "field" character. *False Silver leaf* is occasionally found in apples, "Grenadier," "Bramley's Seedling," *Camellia Sasanqua* var., *Koelreuteria paniculata*, and rarely on cultivated varieties of Cherries, Peaches and Plums. Trees and shrubs which have suffered from *False Silver leaf* for one or two seasons have been noted to resume their normal appearance the following year when improved cultural treatment has been applied.

The microscopic examinations and the primary preparations for the inoculation experiments were carried out under the personal supervision of Prof. V. H. Blackman, to whom I am much indebted for assistance and valuable suggestions in many directions.

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Explanation of Text Figures.

All the figures have been reduced by one half for reproduction.

1. Longitudinal section through the wood of a silvered sucker of "Brompton Stock," showing hyphae of *S. purpureum* in a vessel, with two distinct clamp connections. × 1000 times.
2. Longitudinal section through the wood of *Prunus triloba* var. *flore pleno*, showing hyphae of *S. purpureum* in the xylem vessels bordering the cambium. In one case the hyphae pass through the discoloured area. The cambium cells have fallen apart. × 1000 times.
3. Longitudinal section through the wood of a silvered Apple (said to be "Bramley's Seedling"), showing abundant hyphae in the wood vessels, with numerous clamp connections. The hyphae are unusually irregular in form. × 1000 times.
4. Longitudinal section of a silvered branch of *Spiraea japonica* var. *glabrata*, showing the hyphae in the wood vessels. × 1000 times.
5. Longitudinal section of a diseased root of *Neviusia alabamensis*, showing presence of hyphae and alternate discoloration of the cells. × 1000 times.
6. Longitudinal section of a silvered shoot of *Neviusia alabamensis*, with hyphae in the xylem vessels. × 1000 times.
7. Longitudinal section of a silvered shoot of *Ribes cereum*, showing the hyphae and pronounced discoloration in the wood vessels. × 1000 times.
8. Radial longitudinal section of the xylem vessels of *Laburnum vulgare*, showing deep discoloration and abundant hyphae of *S. purpureum*. × 1000 times.

Description of Plate VIII.

Fig. 1. A sterilized block of Plum wood upon which a piece of *Stereum purpureum* had been placed. The figure shows that the discoloration extends beyond the region of the hyphae; (1) indicating the extent of the discoloration, (2) the limit of hyphae, and (3) the portion of fructification placed on the wood.

,, 2. Branch of *Prunus lusitanica*, showing silvering and curling of the leaves. The letter x indicates that the upper epidermis has been detached from the palisade cells.

Fig. 3. A sucker of "Common Plum" stock, showing parallel, sometimes tortuous streaks of discoloration.

,, 4. Fructifications of *S. purpureum* growing on a living branch of *Prunus triloba* var. *flore pleno*.

,, 5. Fructifications of *S. purpureum* growing on a living branch of Apple tree said to be "Bramley's Seedling."

XVII.—DIAGNOSES AFRICANAE: LXXII.

1631. Kalanchoe densiflora, *Rolfe* [Crassulaceae]; affinis *K. crenatae*, Harv., sed floribus minoribus et cymis densioribus distincta.

Herba succulenta, erecta, glabra, 0·5-1·1 m. alta. *Caulis* simplex, strictus, crassiusculus, subteres. *Folia* opposita, petiolata, ovata, obtusa, crenata, viridia, 7-10 cm. longa, 6-7·5 cm. lata; petioli circiter 1 cm. longi. *Cymae* pedunculatae, erectae, 3-5 cm. latae, densiflorae, in paniculam corymbosam 10-12 cm. latam dispositae. *Bracteae* lineares, acutae, 4-5 mm. longae. *Pedicelli* circiter 3 mm. longi. *Calyx* 4-partitus, 5 mm. longus; lobi subulati, acuti, 5-6 mm. longi. *Corollae* tubus 1 cm. longus, basi ventricosus, superne tubulosus; lobi ovati, apiculati, 3 mm. longi, flavi, margine incurvi. *Stamina* inclusa.

Tropical Africa. British East Africa: Limuru, 2250 m., in short grass and bushland, *J. D. Snowden* 556. Said to be erect or nearly so, 2 to 4 ft. high, and with yellow or reddish flowers.

1632. Anisophyllaea tomentosa, *Rolfe* [Rhizophoraceae]; affinis *A. fruticulosae*, Engl. et Gilg., sed major et foliis fere duplo longioribus differt.

Ramosissima, ramis juvenilibus dense ferrugineo-tomentosis, vetustis cinereis et striolatis. *Folia* breviter petiolata, elliptica vel ovato-elliptica, obtusa vel subobtusa, basi cuneata, coriacea, primo dense ferrugineo-tomentosa, supra mox subglabra, subtus tomentosa, 5-8 cm. longa, 2-4·5 cm. lata, 5-nervia, jugis 2 lateralibus prominentibus arcuatis et fere ad apicem extensis, venis reticulatis; petioli circiter 5 mm. longi. *Spicae* axillares, numerosae, ferrugineo-tomentosae, 5-8 cm. longae. *Flores* sessiles, numerosi, globosi, ferrugineo-tomentosi. *Sepala* late ovata, 1-1·5 mm. longa. *Petala* 1·5-2 mm. longa, basi oblonga, apice in laciniis filiformibus profunde fissa, lobis involutis. *Fructus* ellipsoideus, sulcatus, circiter 2·3 cm. longus, 1·3 cm. latus.

Tropical Africa. Angola: Malange district, *Gossweiler* 1395, 1396; Bailundo district, Benguella, 1530 m., *Wellman*. Belgian Congo: at Katanga, *Ringoet* 56. Native name, "*Mufungo*."

1633. Scyphosyce pandurata, *Hutchinson* [Moraceae]; affinis *S. Mannianae*, Baill., sed ramulis glabris cortice brunneo transverse rupto, foliis e medio ad basin abrupte angustatis superne late ovatis et sensim acuminatis differt.

Ramuli graciles, glabri, cortice sulcato transverse rupto. *Folia* pandurata, parte superiore late ovata et sensim obtuse acuminata, basi e medio abrupte angustata, 10-13 cm. longa, 4-5 cm. lata, chartacea, integra, supra pallide viridia, infra pallidiora, utrinque glabra; nervi laterales utrinsecus circiter 10, a costa media angulo lato abeuntes, intra marginem arcuati et conjuncti; venae infra laxae, stramineae; petioli 4-6 mm. longi, curvati, glabri; stipulae persistentes, lanceolatae, acute acuminatae, 6 mm. longae, 3 mm. latae, submembranaceae, sicco purpureo-brunneae, glabrae. *Receptacula* axillaria, solitaria, pedunculata, ellipsoideo-obconica, circiter 4 mm. longa, glabra; pedunculi 5-8 mm. longi, minute puberuli. *Antherae* e receptaculo exsertae, vix 1 mm. longae.

Tropical Africa. Southern Nigeria: Oban, *Talbot* 1315, 2317.

1634. Kniphofia Snowdeni, *C. H. Wright* [Liliaceae-Hemerocalleae]; a *K. longistyla,* Baker, perianthio pubescente differt.

Folia linearia, 1 cm. lata, glabra, circiter 15-nervia, integra, marginibus hyalinis. *Pedunculus* 30 cm. altus, cylindricus; spica 25 cm. longa; bracteae ovatae, longe acuminatae, 5 mm. longae. *Perianthium* 2·3 cm. longum, leviter curvatum, supra ovarium constrictum, extus pubescens, costis validis instructum, rubrum vel luteum; lobi rotundati, obtusi, 2 mm. longi et lati. *Antherae* inclusae. *Ovarium* conicum; stylus triquetrus, demum exsertus.

Tropical Africa. Uganda: Mount Elgon, 2440-3060 m., in short grass and small bush land, *J. D. Snowden* 437.

1635. Eriocaulon recurvifolium, *C. H. Wright* [Eriocaulaceae]; *E. Hanningtoni,* N. E. Br., affinis, pedunculis obtuse triangularibus pilosis differt.

Acaulescens. *Folia* plura, rosulatim disposita, subulata, recurvata, 1·2 cm. longa, 0·4 mm. lata, subtus incana, supra parte basali pubescentia, parte superiore verruculosa. *Pedunculus* obtuse triangularis, pilosus, usque ad 13 cm. longus; vagina 1·5 cm. longa, acute 2-dentata, glabra; receptaculum pedicellique pilis sericeis 2 mm. longis vestita; bracteae late ovatae, quam flores breviores, glabrae. *Flos* ♂:—*Sepala* 3, uniformia, ovato-lanceolata, 1 mm. longa, acuminata, subtus hyalina, supra dilute brunnea, sparse ciliata. *Petala* nulla. *Filamenta* connata; antherae 6, subglobosae, albae. Flos ♀:—*Sepala* 3, lanceolata, acuta, concava, curvata, 3 mm. longa. *Petala* 3, obcuneata, 1·5 mm. longa, obtusa, sparse ciliata, eglandulosa. *Ovarium* breviter stipitatum, oblongo-ovoideum, 3-loculare; stylus ovario paullo longior, apice penicillatus.

Tropical Africa. Belgian Congo: Atené, January, 1914, *H. Vanderyst,* 3133.

1636. Brachiaria nana, *Stapf* [Gramineae-Paniceae]; *B. ramosae,* Stapf, affinis, sed habitu nano, spiculis minoribus laevissimis, anthoecio infero valvula destituto distincta.

Annua (semper ?), 3-5 cm. alta, caespitosa. *Culmi* primarii prostrati, subgraciles, multinodi, radicantes, apice adscendentes, dense foliosi, ramosi, internodiis 3-6 mm. longis ob vaginas emarcidas evanescentes tandem denudatis glabris vel minute puberulis, nodis annulatim incrassatis; rami vel culmi secundarii similes, nisi breviores (vel brevissimi), sub anthesi crebre ramulosi ramulis floriferis, ramis ramulisque dense fasciculatis. *Foliorum* vaginae pallidae, subscariosae vel superiores subherbaceae, praeter margines dense ciliatos glabrae laevesque vel parce minute pubescentes; ligulae ad marginem ciliatum reductae; laminae e basi rotundata vel subcordata lanceolatae, acutae, 1-1·5 cm. longae, 3-5 mm. latae, rigidulae margine conspicue cartilagineo scaberulo, pallide virides, glaberrimae vel parce pubescentes, supra dense tenuiter multinerves, subtus nervis primariis 3-5 distinctis. *Paniculae* folia summa haud vel vix excedentes, 1·2-2 cm. longae, ramis perpaucis suberectis vel ad racemum simplicem redactae; axis primaria, ut racemorum rhachis et pedicelli, glabra, ad angulos scabra; rhachis triquetra, circiter 0·4 mm. lata, internodiis 1-1·5 mm. longis; pedicelli praeter summum brevissimi, solitarii. *Spiculae* ovato-lanceolatae vel oblongae, acutae, circiter 2·25 mm. longae, pallide virescentes vel purpureo-suffusae, laevissimae. *Gluma* inferior perlate ovata, subacuta, hyalina, obscure 3-nervis, trientem spiculae aequans, superior ambitu spiculae, tenuiter 7-nervis. *Anthoecium inferum* ad valvam glumae superiori simillimam sed 5-nervem reductum. *Anthoecium superum* ♀ ambitu elliptico-oblongum, subacutum, 1·6 mm. longum, albidum, valva valvulaque tenuissime rugulosis; antherae 0·8 mm. longae.

Madagascar. Dry plains near Onilahy, *Perrier de la Bathie* 107.

Barren specimens of what is probably the same species were collected by Dr. Coppinger on Cerf Island, Providence Reef, North of Madagascar. They exhibit the same mode of growth, but the leaf-blades are much less rigid, narrowed towards the base, always quite glabrous and up to 3·5 cm. by 5-7 mm. The tufts are 5-7 cm. high. The affinity with *B. ramosa* is quite clear and one might consider the species described here as an extremely stunted condition of it if it were not for the smaller, narrower, and very smooth spikelets and their more reduced lower floret.

1637. Panicum uvulatum, *Stapf*, [Gramineae-Paniceae]; inter species gregis *P. parvifolii*, Lam., spiculis ad apices paniculae ramorum longorum tenuiter filiformium dense congestis distinctum.

Perenne (?). *Culmi* pergraciles, multinodi, e basi saepe longe vagante radicante adscendentes, ramosi, ramis partis prostratae culmos secundarios primariorum indole referentibus, internodiis 1·5-3 cm. longis laevissimis inferioribus demum denudatis. *Foliorum* vaginae arctae, tenuiter striatae, 1-2 cm. longae, ad os barbulatae et superne ad margines ciliolatae, caeterum glabrae, rarius tenuissime parce pubescentes vel ad nodos pilosae, inferiores demum emarcidae et delabentes; ligulae brevissimae,

rotundatae, hyalinae; laminae lanceolatae vel lineari-lanceolatae, basi breviter contractae, apicem versus longiuscule attenuatae, acutissimae, 2-4 cm. longae, 3-7 mm. latae, oblique patentes, planae, tenues, glaberrimae, ad margines scaberulae vel sublaeves, nervo medio tenui subtus albido, lateralibus crebris tenuissimis primariis (utrinque 3) vix distinctis. *Inflorescentia* foliata, e panicula terminali et pluribus (ad 5) lateralibus e foliorum normalium axillis ortis composita, gracillima; paniculae laterales inferiores pedunculo tenuiter filiformi 5-7 cm. longo suffultae, ramis primariis 3-1 remotis; ramus infimus saepe longiusculus, valde divergens (inde panicula quasi furcata) inferne plerumque longe indivisus, tunc quasi bifidus, ramulum subaequilongum edens, ramo ramuloque apice iterum divisis et ibi spiculigeris, spiculis in glomerulos uviformes 7-4 mm. longos ovoideos congestis; rami sequentes similes nisi parte indivisa breviore vel brevissima vel nulla et tunc quasi trifidi; panicula terminalis lateralibus similis sed ramis sursum magis gradatim abbreviatis minusque divergentibus; pedicelli tenuissimi, ad 1 mm. longi, laeves, apice obscure discoideo-dilatati. *Spiculae* oblongae vel elliptico-oblongae, acutae, 1·5 mm. longae, viridulae, glaberrimae. *Glumae* dissimiles, tenuiter subherbaceo-membranaceae; inferior ovata, acuta, basi amplectens, 1-nervis, circiter 2/5 spiculae aequans, superior ambitu spiculae, vel paulo brevior, 3-sub-5-nervis. *Anthoecium inferum* ad valvam glumae superiori similem 5-nervem reductum. *Anthoecium superum* ♀, elliptico-oblongum, subacutum, 1·3 mm. longum; valva valvulaque tenuiter crustaceae, laevissimae, nitidae, pallide olivaceo-virides.

Madagascar. Between Tamatave and Antananarivo, *Meller*. Central Madagascar, without precise locality, *Baron* 660, 4099. Twohimanitra forest, *Forsyth Major* 91; basin of the Makitana river, *Perrier de la Bathie* 68 bis.

1638. Panicum epacridifolium, *Stapf* [Gramineae-Paniceae]; affine *P. parvifolio*, Lam., habitu, inflorescentiae depauperatae ramis patulis brevibus 2-1-spiculatis, spiculis paulo majoribus, glumis minute nigro-verrucosis distinctum.

Perenne ? *Culmi* prostrati, graciles, radicantes vel arcuati (penduli ?), dorsiventrales, permultinodi, ad 15 cm. longi, ramosi, per totam longitudinem vaginati, nisi in inferiore parte ob vaginas ramis evolutis repulsas hinc inde denudati, glabri. *Foliorum* vaginae firmulae, striatae, molliter hirsutae, subarctae, 4-5 mm. longae; ligulae ad marginem ciliolatum reductae; laminae secundae, ovato-lanceolatae, acutissimae, subpungentes, 6-7 mm. longae, 3 mm. latae, rigidae, striatae, hirsutae. *Paniculae* plerumque ramos ad 6 cm. longos terminantes, magis minusve exsertae, circiter 2 cm. longae, axi primario ut ramis 2-4 patulis vel subdeflexis, 4-1 mm. longis 2-1-spiculatis glabro, tenuiter angulato; pedicelli ramorum laterales si adsunt breves vel perbreves, terminales 3-4 mm. longi. *Spiculae* luride virides, ovato-vel oblongo-lanceolatae, acutae, circiter 2 mm. longae, glabrae. *Glumae* inaequales, tenuiter subherbaceae, verrucis saepe atris minutis magis minusve conspersae; inferior

late ovato-elliptica, acuta, ultra 0·5 mm. longa, distincte 3-nervis, superior longitudine spiculae, 5-nervis. *Anthoecium inferum* ad valvam glumae superiori persimilem redactum. *Anthoecium superum* ♀, elliptico-vel oblongo-ovatum, acutum, 1·7 mm. longum, olivaceum, laevissimum, nitidum; valva valvulaque crustaceae, haec colore magis saturato. *Antherae* 0·8 mm. longae.

Madagascar. On rocks near Antsirabe, 2000 m., *Perrier de la Bathie*. Central Madagascar, without precise locality, *Baron* 4318.

1639. Panicum bambusiusculum, *Stapf* [Gramineae-Paniceae]; affine *P. parvifolio*, Lam., sed habitu, spiculis hirsutiusculis, gluma inferiore spiculam subaequante distinctum.

Perenne, ut videtur, vagans, teste collectore 1-2 m. altum. *Culmi* teretes, ad 1·5 cm. diametro, laevissimi, e nodis hincinde radicantes, internodiis ad 7 cm. longis purpurascentibus, denudati, ramosi, ramis primariis vel secundariis a basi saepe copiose iteratim ramulosi, ramulis in fasciculos collectis; ramuli multinodes, graciles, ad 6 vel interdum 8 cm. longi, per totam longitudinem vaginati, vel inferne ob vaginas repulsas denudati, internodiis demum 7-5 mm. longis. *Foliorum* vaginae culmorum et ramorum primariorum arctae, tenuiter striatae, laeves, praeter margines ciliolatos glabrae, 2·5-1·5 cm. longae, ramulorum ad margines longe ciliatae, 8-7 mm. longae; ligulae ad marginem tenuissimum glabrum redactae; laminae culmorum ovato-lanceolatae vel lanceolato-lineares, semper basi rotundatae vel subcordatae et semi-amplexicaules, tenuiter acuminatae, 6-2 cm. longae, 7-5 mm. latae, firmulae, florendi tempore emarcidae, glabrae, tenuiter multinerviae, ramulorum multo minores, 1-10 mm. longae, 3·5-3 mm. latae, rigidulae, ad margines e tuberculis minutis longe ciliatae, caeterum glabrae vel parce pilosae, nervis approximatis, venulis transversis brevissimis prominulis. *Panicula* ambitu ovata, 2-1·5 cm. longa, ad 1 cm. lata; axis uti rami ramulique superne undulato-flexuosus, glaber, laevis; rami ramulique obliqui, graciles vel gracillimi; pedicelli 1·5-2 mm. longi, apice minute discoidei. *Spiculae* lanceolato-oblongae, acute acuminatae, ad 1·8 mm. longae, luridae vel pallide virides. *Glumae* similes, tenuiter subherbaceae, tuberculato-hirsutulae, inferior paulo minor, 3-nervis, superior 5-nervis. *Anthoecium inferum* ♂; valva glumae superiori simillima; antherae 0·8 mm. longae. *Anthoecium superum* ♀, ellipticum, acutiusculum, 1·2 mm. longum, albidum, laevissimum.

Madagascar. Without precise locality, *Gerrard* 75.

1640. Rutenbergia Usagarae, *H. N. Dixon* [Musci-Rutenbergieae]; *R. borbonica*, Besch., cui proxima, differt habitu robustiore, foliis longioribus frondem latiorem instruentibus, caulibus inferne haud defoliatis, costa multo angustiore, cellulis pellucidis. A *R. madagassa*, Geh. et Hpe, habitu alieno multo laxiore robustiore, foliis medio leniter longitudinaliter plicatis, nec transverse corrugatis, marginibus fortius serrulatis.

Tropical Africa. Usagara: Itumba, on woody branches, *Rev. A. North Wood*.

XVIII.—BOTANICAL RESULTS OF SWEDISH SOUTH AMERICAN AND ANTARCTIC EXPEDITIONS.

W. B. Turrill.

The appearance of Dr. Skottsberg's final publication resulting from the Swedish Expedition to Patagonia and Fuegia, 1907-1909, gives a good opportunity for summarizing the recent botanical work of Swedish botanists in the southern part of the American continent and its neighbouring islands, in the Antarctic, and in certain of the subantarctic islands. Their work is of special interest to British botanists for two reasons. In the first place the Falklands and South Georgia are included in the British Empire, and secondly, some of the areas visited by the Swedish expeditions were made classical by the researches of Darwin, Hooker, and others of our countrymen, who were the first to suggest solutions to many of the problems again attacked in the series of books and papers here reviewed. These chiefly record the results obtained during two expeditions to the Southern Hemisphere. The one, known as the "Swedish South Polar (or Antarctic) Expedition," was under the leadership of Nordenskjöld, and took place between the years 1901 and 1903; the second, with the title "Swedish Expedition to Patagonia and Fuegia," was arranged by Dr. Skottsberg, and lasted from 1907 to 1909.

The following bibliographical list gives the publications dealing with the botany of these two expeditions:—

(1) Skottsberg, "The Geographical Distribution of Vegetation in South Georgia," Geogr. Journ. Nov. 1902, p. 498.

(2) Skottsberg, "On the Zonal Distribution of South Atlantic and Antarctic Vegetation," Georgr. Journ. Dec. 1904, p. 655.

(3) Stephani, "Wissenschaftliche Ergebnisse der Schwedischen Südpolar-Expedition 1901-1903." Band IV. Lief. 1 (1905). "Hepaticae."

(4) Skottsberg, Ibid. Lief. 2 (1905). "Feuerländische Blüten."

(5) Skottsberg, Ibid. Lief. 3 (1905). "Die Gefässpflanzen Südgeorgiens."

(6) Skottsberg, Ibid. Lief. 4 (1906). "Zur Flora des Feuerlandes."

(7) Foslie, Ibid. Lief. 5 (1907). "Antarctic and Subantarctic Corallinaceae."

(8) Skottsberg, Ibid. Lief. 6 (1907). "Zur Kenntnis der subantarktischen und antarktischen Meeresalgen."

(9) Ekelöf, Ibid. Lief. 7 (1908). "Bakteriologische Studien."

(10) Cardot, Ibid. Lief. 8 (1908). "La flore Bryologique des Terres Magellaniques, de la Georgie du Sud et de l'Antarctide."

(11) Skottsberg, Ibid. Lief. 9 (1909). "Pflanzenphysiognomische Beobachtungen aus dem Feuerlande."

(12) Skottsberg, Ibid. Lief. 10 (1909). "Studien über das Pflanzenleben der Falklandinseln."

(13) Darbishire, Ibid. Lief. 11 (1912). "The Lichens."

(14) Skottsberg, Ibid. Lief. 12 (1912). "The Vegetation of South Georgia."

(15) Skottsberg, Ibid. Lief. 13. (1912). "Die Vegetationsverhältnisse des Graham Landes."

(16) Cardot, "Notice Prélim. sur les Mousses," Bull. Herb. Boiss. 2nd. sér. V. 1905, p. 997, and l.c. VI. 1906, p. 1.

(17) Skottsberg, "Swedish Magellanian Expedition 1907-1909," Preliminary Reports, Georgr. Journ. June 1908, p. 640; Nov. 1908, p. 485, 591; March 1909, p. 289; Oct. 1909, p. 409.

(18) Skottsberg, "Bot. Ergb. der Schw. Exped. nach Patagonien u.d. Feuerlande, 1907-09." I. "Übersicht über die wichtigsten Pflanzenform. Sudamer. S. von 41°." Svensk. Vet. Akad. Handl. Bd. 46, No. 3, 1910.

(19) Stephani, Ibid. II. "Die Lebermoose." l.c. Bd. 46, No. 9, 1911.

(20) Skottsberg, Ibid. III. "A Botanical Survey of the Falkland Islands." l.c. Bd. 50, No. 3, 1913.

(21) Skottsberg, Ibid. IV. "Studien über die Vegetation der Juan Fernandez Inseln." l.c. Bd. 51, No. 9, 1914.

(22) Skottsberg, Ibid. V. "Die Vegetationsverhältnisse langs der Cordillera de los Andes S. von 41° S. Br." l.c. Bd. 56, No. 5, 1916.

(23) Skottsberg, "The Wilds of Patagonia." (London, Edward Arnold, 1911.)

Juan Fernandez. (21, 23.)*

The Juan Fernandez group consists of two large islands, Masatierra (often called Juan Fernandez) and Masafuera, and the small island of Santa Clara, which lies off the west point of the Masatierra. Masatierra is 366 knots west of Valparaiso and Masafuera 92 knots further west. Both are high, mountainous and volcanic islands.

In the systematic list given by Skottsberg, 117 species are recorded, five new ones being described. The indigenous species of flowering plants number 105. Of these 72 (68·5 per cent.) are endemic and 33 (31·5 per cent.) non-endemic. There are 74 genera, of which 11 (15 per cent.) are endemic, and 38 families are represented, of which one (the *Lactoridaceae*) is endemic. The number of Pteridophytes is 43 (30 per cent. of the higher flora); 12 species (28 per cent.) are endemic, and there is one endemic genus. Of the 72 endemic Phanerogams 35 have their nearest relatives in South America, especially in Chile, 14 are clearly related to Polynesian, Australian or New Zealand species, two may have been derived from either Chilean or western species, while the remainder are of uncertain affinity or isolated.

Juan Fernandez belongs to the oceanic type of islands since it lacks land mammals, reptiles and amphibia; Gymnosperms, Orchids, *Liliaceae*, and *Amaryllidaceae* are also absent, and the

* The figures in brackets refer to the bibliographical list.

Leguminosae are represented by only one species (*Sophora tetraptera*). Quensel, who was with Skottsberg, found the islands were composed, as far as he could observe, solely of volcanic material, of uncertain age, but probably belonging to early Tertiary times. Skottsberg considers that colonization from existing neighbouring lands, Chile, Polynesia, New Zealand, etc., will not alone account for the existing flora, since the relatively short time which has passed since the present islands appeared would not be sufficient for the development of such isolated types as *Lactoris* and *Robinsonia*. He believes that the old element did not originate in the Juan Fernandez group, but is older than these islands and once spread over a large area in Polynesia, Chile, etc., subsequent changes in the Quaternary Period, however, altered the floras of these countries and isolated that of Juan Fernandez. The existence of more land in the Pacific in Tertiary times may have given developmental centres for a fauna and flora, whose scattered remains now especially inhabit the oceanic islands. Many things suggest that in spite of their recent volcanic nature the islands are the remains of a greater island or group of islands, but nothing definitely suggests that they formed in earlier times part of a transoceanic land-bridge or of a great Pacific continent.

The forest consists of evergreens, except *Berberis corymbosa*, which was leafless in July and August. It is a typical rain-forest, but is not sub-tropical, since it lacks obligatory epiphytes and lianes. The presence of two climbing ferns (*Arthropteris altescandens* and *Blechnum Schotii*) is interesting, and in general appearance the Valdivian forest is strongly recalled by the presence of such types as *Myrtaceae, Drimys, Sophora, Escallonia, Pernettya, Rhaphithamnus*, and *Chusquea*. On the other hand the lack of species of *Nothofagus*, so common in Chile, is striking, as is also the presence of such types as *Fagara, Psychotria, Boehmeria* and *Santalum*, which are absent from the Chilean rain-forest. These types are tropical or subtropical, but they do not change the mainly temperate character of the rain-forest. The absence of *Coniferae* is common to Juan Fernandez and many other oceanic islands. The Composite trees (*Rhetinodendron, Robinsonia, Dendroseris*, etc.) and other "feather bushes" give a characteristic facies to the vegetation.

A graphic account is given of a visit to the last remaining tree of the native sandle-wood (*Santalum*). The tree had only one living branch, and the reader is made to share with the author the intense emotions of a botanist witnessing the death of a species.

America south of 41° S. (4, 6, 11, 18, 22, 23.)

The results of the Swedish expeditions in the southern part of South America are extensive and important from the several aspects of systematic, geographical and ecological botany. In the last published work here dealt with, Skottsberg has brought together much of the information obtained during the four or five years he spent in the Southern Hemisphere, and has further modified some of the views he published in previous papers.

In the systematic list (22) 788 species are dealt with, many of them accompanied by valuable taxonomic notes. Thirty species new to the science are described, and two new genera, namely, *Pycrophyllopsis*, an isolated genus of the *Caryophyllaceae*, which is compared with *Colobanthus*, but is not closely related, and *Xerodraba*, a genus placed near *Draba* in the *Cruciferae*.

The southern part of Temperate South America may be phytographically divided up into four botanical areas: The Valdivian, the Cordilleran between 36° 30′ and 54° 40′, the Patagonian-Fuegian steppe, and the Magellanic.

Accepting the main divisions suggested by Engler (Engler and Gilg, Syllabus der Pflanzenfam. pp. 356-357), the following subdivisions are in accord with Skottsberg's results:—

III. Central and South American Floral Realm.
  C. Andine Region.
    1. Valdivian Forest Province, 36° 30′-48°.
      (*a*) Zone of Coast Cordilleras and the longitudinal valleys between 36° 30′ and 41°.
      (*b*) Zone of the islands and the western slopes of the Cordilleras between 41° and 48°.
    2. Andine-Patagonian Province.
      (*a*) Cordillera Zone between 36° 30′ and 54° 40′.
        (i.) Northern district up to 41°.
        (ii.) Southern district of the Patagonian-Fuegian mountains.
      (*b*) Patagonian-Fuegian steppe-zone between 41° and 54°, stretching eastwards up to the Atlantic Ocean.

IV. Austral-Antarctic Floral Realm.
  A. South American Subantarctic Region.
    (*a*) Magellanic Forest Zone of the West Patagonian-Fuegian coasts and islands between 48° and 56°.
    (*b*) Woodless island zone of the Falkland Islands.

The climate of the Valdivian Region is characterised by high winter temperature, great precipitation, especially in the winter, and predominating westerly and north-westerly winds. In brief, it may be said that this district has a warm-temperate rain-climate, with comparatively little difference between summer and winter. The district of the West Patagonian canals and islands (the Magellanic Region) may be said to have a cold-temperate, very stormy climate, with very little difference between summer and winter, and with much rain in all parts of the year. The eastern slopes of the Andes are poor in rainfall, and this is also true of Patagonia. Unfortunately the relatively few published records nearly all concern coast-stations, and since these have a less extreme climate than the inland districts they are not sufficient to give a general idea of the climate, which is largely of the continental type. On the Patagonian-Fuegian tableland there is slight precipitation and dry winds, and clear skies are the rule.

In one of his earlier works Skottsberg designates the Valdivian Forest as "the forest which is rich in species." Prominent among the tall trees are *Nothofagus Dombeyi*, *N. nitida*, *Laurelia serrata*, *Drimys Winteri* (the only member of the *Magnoliaceae* found in Chile), *Aextoxicon punctatum*, *Myrceugenia planipes* and the conifers *Fitzroya patagonica*, *Libocedrus tetragona*, *Saxegothea conspicua* and *Podocarpus nubigena*. There are many smaller trees and shrubs, amongst which may be mentioned *Guevina Avellana*, *Lomatia ferruginea*, *Embothrium coccineum*, *Weinmannia trichosperma*, *Sophora tetraptera*, *Aristotelia Macqui*, *Pernettya vernalis*, *P. mucronata*, *Gaultheria myrtilloides* and *Berberis Darwinii*. Species of *Chusquea* (bamboos) play a great rôle. Lianes are conspicuous and include *Griselinia racemosa*, *G. ruscifolia*, *Asteranthera ovata*, *Mitraria coccinea*, *Eccremocarpus scaber*, *Mutisia* spp., *Hydrangea integerrima*, *Boquila trifoliolata*, *Ercilla spicata*, *Elytropus chilensis*, and *Cynanchum lancifolium*. Parasites, except Fungi, are not common, but epiphytes occur in astonishing numbers of forms, the most common being Cryptogams, but species of *Luzuriaga*, *Rhodostachys*, *Peperomia*, *Mitraria*, *Asteranthera*, and *Griselinia* are found. The ferns include many *Hymenophyllaceae*, *Blechnum* (*Lomaria*) *magellanicum*, a tree-fern with Cycad-like form, and *Lophosoria glauca*.

The Magellanic (subantarctic) region has rain-forest over a very limited area, reaching only up to a few hundred metres. Even below the tree limit all the land is not forest-clad, for with the dark-green wooded areas there alternate nearly treeless moors where *Marsipposperm*um *grandiflorum* is dominant. The wind is here the most important cause of the distribution of plant associations. In West Patagonia and Fuegia there is a maritime forest limit outside which the oceanic heath is developed as a cushion-heath. High trees do not occur in the Magellanic rain-forest. *Nothofagus betuloides* is not above 10-12 m. high, *Drimys* has an average height of 10 m., *Maytenus* is smaller, *Embothrium* at most 5-6 m., *Tepualia* seldom above 3-4 m. and *Pseudopanax laetevirens* 3-4 m. The only conifer which reaches Fuegia is *Libocedrus tetragona*. The absence of *Chusquea* spp. and true lianes is noteworthy, and there are no phanerogamic epiphytes. Dwarf shrubs are important in the moors and heaths and include *Empetrum rubrum*, *Gaultheria serpyllifolia*, and *Myrteola nummularia*. Cushion plants occur generally in the rocky coast district and are definitely related to the severe westerly gales which prevent the growth of trees. The cushion-plants include *Astelia pumilia*, *Bolax Bovei*, *Caltha dioneaefolia*, *Donatia fascicularis*, *Gaimardia australis* and *Abrotanella submarginata*. Near the glaciers the vegetation has a subalpine character and is a moss and lichen heath with *Empetrum rubrum*. *Marsipposperm*um often occurs gregariously. Where the ground is flooded, meadows are found with *Hierochloa* and *Gunnera magellanica*. Alpine species of *Abrotanella*, *Cerastium*, *Epilobium*, *Geum*, *Lagenophora*, *Oxalis* and *Saxifraga* were observed.

Over the lower passes and through the Trans-Andine valleys the oceanic climate of the west coast passes inwards, and is

accompanied by the rain forest, but this generally loses some of the elements most characteristic of the coastal districts, and then forms a transition between the evergreen rain- and deciduous summer-forest. In North and Central Patagonia (41° to 44° S.) a forest of *Libocedrus chilensis* is interposed between the rain- and summer-forest. In other parts of the transition area *Nothofagus betuloides* occurs as a tree, reaching considerable dimensions.

The Andine forest girdle below the *Libocedrus* forest, that is from 44° to 55°, is especially characterised by *Nothofagus Pumilio*. Evergreen shrubs forming much of the undergrowth include *Berberis ilicifolia*, *B. Pearcei*, *Embothrium coccineum*, *Chilotrichum diffusum*, *Escallonia rubra*, *E. virgata*, *Maytenus disticha*, and *Pernettya mucronata*. Lianes are rare. Phanerogamic epiphytes are wanting, but parasitic species of *Myzodendron* are nearly always present. The herbaceous flora is richer than that of the rain-forest. *Nothofagus antarctica* occurs in all kinds of localities.

The whole of the Pampas area to the east of the Andes is covered with sand and gravel of Tertiary strata, and is a district poor in rainfall. There is a distinct periodicity of the vegetation, due to the marked winter-rest period. The dominating plant formation is the steppe. Nearly all the steppe plants are strongly xerophytic, and all kinds of devices for the reduction of transpiration are to be found. There are no trees, but shrubs are represented by *Embothrium lanceolatum*, *Berberis* spp., *Escallonia* spp., *Adesmia* spp., *Anarthrophyllum rigidum*, *Schinus dependens*, *Discaria* spp., *Verbena* spp., and *Lycium pulverulentum*. The floral richness of the steppes is striking. Flowers noteworthy for individual richness of colour are rare, but innumerable small flowers take their place. Amongst the most beautiful may be mentioned species of *Chloraea*, *Senecio*, *Mutisioideae*, *Embothrium*, *Verbena*, *Tristagma* and *Opuntia*. Cushion plants are abundant, and Skottsberg records 92 species belonging to 40 genera, placed in 24 families.

The following associations are to be met with: The *Mulinum spinosum* steppe, the grass steppe (*Festuca-Mulinum* association), the shrub steppe (especially found on the eastern shores of the great Andine lakes), and the vegetation of the desert-like ground.

Great tablelands (Mesetas) are raised above the pampas, and here Alpine heaths and meadows are found, including dwarf shrubs, rosette-plants, cushion plants and grass clumps. Many of the Alpine plants are noteworthy for their beautiful flowers with clear colours. Thus species of *Nassauvia* have white and lilac flowers, *Calandrinia rupestris* has orange, *Calceolaria uniflora* carmine, yellow and white, *Leuceria Hoffmannii* carmine, *L. leontopodioides* rose, *Perezia pilifera* blue, *Viola auricolor* golden-yellow, and the cushions of *Saccardophytum* and *Benthamiella* are covered with small yellow or white flowers.

It has been seen that the flora of the rainy coastal area of West Patagonia and Fuegia can be divided into two distinct districts—the Valdivian and the Magellanic. To the first belongs the greater part of the old Chilean floral element, which has its affinities in

Tropical America, and took on its special character during the elevation of the Andes, so that the existing differences between Chile on the one hand and Brazil-Argentine on the other are fundamental. The old Antarctic element is also important in this forest-flora, giving several of the species of trees, as *Eucryphia cordifolia*, *Nothofagus Dombeyi*, *Fitzroya patagonica*, and *Laurelia* spp. The Magellanic flora is composed of the same general elements as the Valdivian, but the Chilean species are less prominent, while the old Antarctic forms are more so. There are in South America remnants of an old Antarctic flora, which is also strongly represented in New Zealand, and also species of a New Zealand flora which is more weakly represented.

Nothing is known of the composition of the vegetation immediately before the Ice Age. It apears from the fossil record of South Patagonia and Fuegia that the climate of the Miocene Period was warmer and damper than that of the present. It is also probable that many types had wider distribution before the climate became too cold than they now have. Thus immediately before the Glacial Period forests of Andine character with *Libocedrus* and *Podocarpus* apparently occurred in the Falklands. The wind conditions were similar to those now existing, that is, the western slopes of the Andes acted as a weather-shield, and were probably covered with evergreen 'beeches.' At the time of maximum glaciation plants emigrated northwards or found refuge in the South Chilean coast cordilleras and also in Chiloe, where many subantarctic types may still be found. With the diminution of the ice the northern species migrated back to their old stations. The first vegetation to establish itself would consist of moor and heath plants with trees of the type of *Nothofagus antarctica*—such vegetation indeed as is found to-day near the great glaciers. Some species may have survived in specially favoured localities, but most of the present flora is more likely to have come (largely returned) from the North.

The Falklands. (12, 20, 23.)

The taxonomic constitution of the Falkland flora is fairly well known, and, except in a few details, Skottsberg's work has added little to the researches of older botanists in this direction. It is in his ecological surveys of the group, and his well-considered accounts of the geographical relationships and origin of the flora that he has chiefly increased our knowledge.

The monotony of the landscape always strikes a visitor to the Falklands. The gently undulating country is scarcely relieved on the hills by an occasional mass of grey, naked quartzite, or in the lowlands by extensive swamps, whose vivid green colour causes them to stand out sharply against the darker heath. The Falklands were never glaciated in the strict sense of the term, but the severer climate of the Glacial Epoch caused the accumulation of great snow-masses in the winter, which melting quickly in spring, flooded the land. The poor vegetation was unable to bind the ground, and great masses of semi-fluid soil originated from the soft weathered sandstone.

These half-fluid masses glided down into the valleys, the fine material was mostly washed out, but the larger blocks of resistant quartzite still remain in heaps and in the well-known "stone-runs" or "stone rivers."

The climate is extraordinarily suitable for peat-formation, and in the extensive swampy areas the peat layers grow slowly and surely, furnishing the inhabitants with their chief fuel. The absence of forests is partly due to the strong wind storms, but since similar storms occur on the Fuegian coasts, which are clad with luxuriant forests, other factors must combine with the winds. The peculiarities of the terrain and soil may be unfavourable for tree growth. The absence of a permanent protective covering of snow during the winter would also be inimical to many plants.

The vegetation may be described as a steppe. The grass-steppe is especially developed, but the grasses are often replaced by *Empetrum rubrum*, and sometimes by *Bolax glebaria*, thus merging into heaths. The characteristic plants of the heath formation are evergreen, and so periodicity is little evident to the eye. In his latter paper Skottsberg subdivides the vegetation into the following associations:

Cortaderia-association is one of the most important types of vegetation in the islands, being commonly developed on dried ground, especially where the subsoil is composed of fine-grained material.

Empetrum-association is also found on comparatively dry ground, being best developed on the mountain ridges and on stony plateaux. It consists of dwarf shrubs, herbs and grasses.

Chiliotrichum-association frequently forms a grey fringe along the streams.

Astelia-association is the Falkland representative of the peat-mosses of high-moor type, but the *Sphagnaceae* are of little or no importance. This association is partly responsible for the immense layers of peat which may reach several yards in thickness.

Rostkovia-association is characteristic of the wettest ground, being confined to the depressions, and corresponds to what is generally termed low-moor.

Cortaderia-Astelia-Rostkovia-association is common on soil intermediate in its moisture content and drainage between the *Cortaderia* association and low-moor.

Blechnum magellanicum-association inhabits ground round the quartzite ridges.

The vegetation of the stone-runs is especially characterised by *Nassauvia serpens*.

The alpine heath with *Empetrum* and *Bolax* covers the hill tops, and most nearly resembles the tundra of South Georgia, Kerguelen, etc. *Azorella Selago* and *Valeriana sedifolia* are confined to the highest summits.

The fresh-water vegetation is not well developed.

The vegetation of the sea-coast has largely altered since the advent of man and the introduction of domestic animals on the islands. The tussock-grass, *Poa flabellata*, once formed the most important feature of coastal plant-life. At present it is only to

be found on un-stocked islands, or in places inaccessible to sheep.

Veronica elliptica, the largest land plant of the Falklands, commonly accompanies and may replace the tussock-grass.

An analysis of the Falkland flora gives the following results:

Group I.—South Patagonian and Fuegian Element. This is by far the largest group, containing 133 species, or 82·1 per cent. of the flora. Although many of the species are confined to sub-antarctic South America, others have a wider distribution.

Group II.—Warm-Temperate element. This is composed of 14 species (8·6 per cent. of the flora), also found in Chile and the warmer parts of South America, and one in the North Temperate regions.

Group III.—Endemic Element. Composed of 15 species (9·3 per cent of the flora).

Hooker knew that most of the Falkland plants point to a Magellanic origin for the flora. Amongst the 82 per cent. of more or less common Magellanic plants there are a number of forest species, while the steppe element is not especially pronounced. The periodicity is much less marked in the Falklands, and a number of species from the rainy, evergreen forests therefore occur. The probable history of the flora may be summarised as follows:—

1. During the Tertiary Epoch the Falklands were raised above their present level, and the elevation may have been sufficient to establish a land connection with South America, even if of short duration.

2. Before the Ice Age coniferous forests of Chilean type existed in the islands, as is shown by the remains of fossil trees of a species of *Podocarpus* and *Libocedrus*, probably *P. salignus* and *L. chilensis*, on West Point island. Large areas, however, were probably even then inhabited by oceanic heath or meadow.

3. Judging from the present distribution of the above conifers the climate was warmer, but not necessarily drier, than now.

4. With the deterioration of the climate which culminated in the Ice Age, the forests disappeared and the tundra-like formation became predominant.

5. The Falklands were never glaciated, but the Ice Age was represented by the period of semi-fluid moving soil. During this time a large number of species may have survived.

6. In post-glacial times many species have probably immigrated from the west.

7. The warm-temperate element in the flora did not survive the period of semi-fluid soil, but immigrated in post-glacial times. This element may have come directly from its present habitat or, more probably, by way of Fuegia, which it may be assumed has undergone post-glacial changes, permitting a number of warm temperate species to extend their boundaries to the south.

South Georgia. (1, 5, 10, 14.)

South Georgia is an isolated, mountainous island lying in the southern part of the Atlantic Ocean and within the limits of the drift of Antarctic icebergs. The island gives a strong impression

of being part of a mountain chain, since it rises abruptly from the ocean, and has a very broken crest of considerable height, with numerous steep peaks, of which Mt. Paget reaches 2000 m. Two distinct periods of glaciations may be traced, and when the ice withdrew from the lowlands for the last time it left considerable deposits of morainic material in the valleys close to the coast. It is on those which have not been washed away that plants especially establish themselves. The present inland ice is of the Alpine rather than of the Antarctic type.

The climate is very similar to that of Fuegia and the Falklands, but the temperatures are lower, the summer shorter and the seasons less well-marked.

If the term "formation" be used in a wide sense all the vegetation of South Georgia may be described as tundra-formation, and the following associations can be recognized: 1. *Poa flabellata* association. 2. The vegetation of the rocky shore. 3. The inland tundra. 4. The swamps. 5. The fresh-water vegetation.

Skottsberg records four species of Pteridophytes and 16 Phanerogams. *Poa flabellata*, the tussock grass, is the most conspicuous member of the flora.

In the first period of glaciation the land was completely covered with ice and no vascular plants could have existed. The land may have been colonised in the interglacial period, and in the second glacial epoch some plants may have survived, or they all may have been exterminated. South Georgia has no endemic Phanerogams, such as are found in Kerguelen, which was never wholly glaciated. There is, therefore, no objection to accepting the view that the vascular flora of South Georgia is post-glacial. Further, there is no evidence of a land connection in post-glacial times with any continental area.

The flora is obviously related to that of Fuegia. The Cryptogams probably reached the island by wind-dispersal of their spores, while the seeds of flowering plants were possibly brought by birds who travelled with the prevailing west winds. It is only necessary to assume the arrival of one species every thousand years since the Ice Age to account for the species now found.

Amongst the mosses there are numerous endemic types which must be regarded as belonging to the preglacial flora. On the other hand, amongst the cryptogams generally there are many Magellanic species, some with circumpolar distribution, some found only in South Georgia and Kerguelen, and some only in South Georgia and the Antarctic continent. This supports the theory that there is here a branch of the old Antarctic flora, of which so many traces are found outside of the Antarctic proper, recalling a time when there was closer connexion than now between the different groups of islands—the South Shetlands, the South Orkneys, the South Sandwich Islands and South Georgia.

Graham Land. (15.)

The climatic conditions of the Antarctic regions are well known to be the most severe in the world. The strong wind storms clear away the snow in places, and if it were not for this no vegetation

other than lichens could exist, for the summer sun rarely raises the temperature above 0° C., and could not melt the snow. The greater part of the time the ground is frozen hard. Since the period during which life-activities may occur is so limited, it is no wonder that most of the mosses remain sterile, and only two flowering plants occur, and these not in such abundance as to give a facies to the flora. The rocks and stony ground may be colonised by crustaceous lichens. Closed patches of moss-tundra are seldom seen, but emerald-green mats of *Prasiola crispa* are found near the sea. Penguins occupy many areas which might have been occupied by plants. The ground is there covered with a half-fluid mass of guano, and no vegetation can exist.

Sixty-two species of mosses are known from the Antarctic continent, and the flora shows the greatest affinity with South Georgia and Magellanic countries. Most of the species are found in the Graham Land area. The flora of Victoria Land is much poorer, but three endemic species, including *Saconeurum glaciale*, representing the only endemic genus, occur both in Graham Land and Victoria Land. The only moss, *Bryum filicaule*, from Kaiser Wilhelm's Land is endemic there.

Geological, zoological and botanical facts are all in favour of a single origin for the scattered floras and faunas of the sub-antarctic and antarctic zone. The existing flora is the remnant of the old antarctic plant-world, but an extension of glaciation occurred in the Antarctic regions, and it is generally agreed that there were no ice-free spots, or even if there were, the temperature would prevent plants from growing. Hence the conclusion is reached that the existing flora has largely returned in post-glacial times to the regions it now occupies.

Cryptogams.

Taxonomically the richest botanical results of the Swedish expeditions are connected with the Bryophyta and Thallophyta. Cardot (10, 16) for the first expedition catalogues 444 species of mosses from the Magellanic region, of which 243 (54·7 per cent.) are endemic, and 48 are new to science. The same author (l.c.) enumerates 80 species collected by Dr. Skottsberg in South Georgia, of which 26 are new. 42 species of mosses are endemic in South Georgia, representing nearly 45 per cent. of the total recorded from that island. From the Antarctic continent 51 species were collected, five being described as new. Cardot was working at Lille on the mosses collected during the second expedition, when war broke out, and nothing had been heard of the collection up to the date of publication of Skottsberg's latest work. Stephani (3, 19) records 78 species of *Hepaticae* from the first expedition, describing five as new.

Darbishire (13) gives the following list for the lichens:—

	Total lichen species known.	Brought back by the Swedish Antarctic Expedition.		
		Total spp.	New locs.	New spp.
From Subantartic America ...	373	101	37	20
„ South Georgia	55	37	28	4
„ Antarctic regions ...	106	46	18	9
By Swedish Antarctic Expedition	—	145	—	33

There is very close affinity between the Antarctic lichen-flora on the one hand and the American and New Zealand on the other hand. South Georgia may be regarded as a half-way house on the road from Subantarctic America to the true Antarctic continent. Practically half the Antarctic species are common also to the Arctic.

For the Algae Skottsberg (8) has given a systematic list, with many valuable notes, of the *Phaeophyceae* of the Antarctic ocean. 53 species are recorded, of which 16 are new, as are eight genera and one family. There is an excellent account of the morphology, anatomy, taxonomy and geographical distribution of *Macrocystis pyrifera*. Foslie (7) has dealt with the Antarctic and Subantarctic *Corallinaceae*, enumerating 13 species, three being new. *Lithothamnion* and *Lithophyllum* are the most abundant genera. The calcareous algae are widely dispersed in the true Antarctic regions, and in some localities occur in considerable numbers of individuals.

Skottsberg has undoubtedly added valuable confirmation to the position taken up by Hooker in the introductory essay to the "Flora Antarctica." The southern part of the American continent is the headquarters of a botanical region whose flora is still found in isolated groups of islands extending 5000 miles to the east, some being nearer to the African and Australian continents than to the American. The existence must be accepted of an old Antarctic or Subantarctic Flora, at one time more continuous, or at least with its now separate parts having had a common origin. In reading Skottsberg's works one is impressed by the effect which the last Ice Age or series of Ice Ages had on the vegetation. The north and south direction of the Andes allowed the southern flora to retreat northwards in South America, and to return again when better conditions prevailed. A comparison between the flora of South Georgia which was, at least once, completely glaciated and that of Kerguelen, which was never completely glaciated, is most instructive in this connection.

The division of Fuegia and Patagonia into clear botanical provinces and zones is a noteworthy addition to geographical botany. Finally, the careful records of the vegetation of Juan Fernandez, the Falklands, and South Georgia, as it is at the present time is more especially important because colonisation is rapidly altering the floral facies of the islands, both by the destruction of native plants and by the introduction of exotic species.

XIX.—THE BOTANIC GARDEN OF PAMPLEMOUSSES.

(With Plates.)

An interesting history of the Botanic Garden of Pamplemousses, Mauritius, written by Mr. W. Edward Hart, Librarian and Curator of the Institute, was published in French in Mauritius in 1916. We are indebted to Mrs. F. R. Durham for the following abridged translation of the more important parts of Mr. Hart's paper.

The Garden has been successively known as Garden of Mon Plaisir, or Mon Plaisir, Jardin des Plantes, Royal Garden, and is now known as the Botanic Garden of Pamplemousses.

The Garden, which now covers an area of about 90 arpents (about 130 acres) started on modest lines, and its present condition of importance is due to the distinguished men who have been associated with its development.

Mahé de La Bourdonnais.—One month after his arrival at the Ile de France (June 5th, 1735), the Governor, François Mahé de La Bourdonnais, together with M. Pierre d'Albert, member of the Conseil Supérieur, bought from M. de Maupin the property of Mon Plaisir in the Pamplemousses District.

In the following year, having become sole proprietor, La Bourdonnais erected in the grounds a château and numerous other buildings, *i.e.*, a Chapel, where M. de Céré (later second Director of the Royal Garden) was baptized in 1837.

At the same time he planted a large part of his domain with vegetables to supply the needs of the "Camp," as the budding town—afterwards Port Louis—was called. A fairly large space was then sown with fatak grass for the raising of cattle, and another area near his residence was cleared for the cultivation of Mandioca, which he had just introduced from Brazil.

These cultivated grounds were soon transformed into a pleasure garden, enriched by fruit trees from Europe and India, to which he gave his special care, until he sold Mon Plaisir to the (French) East India Company on February 14th, 1737.

After La Bourdonnais' departure the whole of the grounds were planted with Chinese mulberry trees, with a view to establishing a silkworm industry. This attempt failed and was abandoned, but it was no easy matter to destroy the useless mulberry trees 30 years later, when it was decided, on Charpentier de Cossigny's resolution, to replace them by a plantation of "black wood," a species of Acacia introduced from the Malabar Coast, and furnishing timber as well as charcoal for the manufacture of gunpowder.

The gardens were entirely neglected until the arrival in 1753 of the naturalist Fusée Aublet, whom the India Company had commissioned to instal a central pharmacy and botanic garden on the Ile de France.

M. Aublet, though an eminent horticulturist and botanist, was unfortunately a man of suspicious and morose disposition, who made himself thoroughly unpopular from the first.

His character and prejudices appear in the preface to his book: "History of the Plants of French Guiana," followed by "Notes on the Plants of the Ile de France":—

"It was considered odd at the Ile de France that I should have been sent there for no fault. I was asked if I had come for a change of air. Immediately I became suspect, and was supposed to be condemning others, while only occupied in fulfilling my professional duties."

Soon after his arrival (August, 1753) Aublet took up his residence at Mon Plaisir, which he renamed Pampelmouze.

Climate, position, and the work already so well done by La Bourdonnais made him select this house for his experiments. He "prepared, sowed, and planted the ground to a great extent, but people, in whose way I stood, destroyed with as much ardour as I had expended in building up, so I was forced to leave this place next autumn (*i.e.*, six or seven months after my arrival) taking with me everything that had been spared and could be transplanted. Pamplemousse was henceforward devoted solely to the culture of vegetables for the Hospital, the Government, and the vessels going to India or returning to France."

"In another property 'Le Réduit,' I collected all I could procure of rare, useful or curious plants. I started a big farmyard, I had considerable grazing grounds, I increased the culture of lucerne and fatak. I planted useful trees, I rounded up all the cattle belonging to the Company (who were losing their produce and were often losing beasts) and had them coralled. I distributed a number of cows among the inhabitants on condition that half the produce should be returned to the Company, thus greatly helping to increase their numbers."

"In the midst of these occupations the gift of a so-called nutmeg tree and of nutmegs by M. le Poivre, caused me much annoyance, as I neither could nor would recognise this tree or its fruit for the true nutmeg of commerce. I reported to the Company to this effect, and thus made many personal enemies, who took their revenge in slandering me."

The M. le Poivre referred to was the traveller and naturalist Pierre Poivre, who landed on the island in 1775 on his second voyage, and introduced some seedling nutmeg trees which he had brought from the Moluccas, and presented to the Conseil Supérieur of the Ile de France.

Aublet persisted in his refusal to recognise these nutmeg trees or to plant them, until formally ordered to do so by the Conseil Supérieur. The nutmegs, however, died. Aublet was suspected of foul play, and it was even whispered that the young plants had been watered with boiling water!

Poivre.—After a series of travels in the Indies, China and Cochinchina, in the course of which he twice visited Mauritius, Poivre returned to France with a store of interesting observations on the Natural History, and with a very perfect knowledge of the customs, language and products of the countries he had visited.

The French Government ordered him to open up direct commercial intercourse with Cochinchina, and to import into the Ile de France and to Bourbon the spices hitherto only cultivated by the Dutch in the Moluccas. In 1767 he was appointed "Intendant Ordonnateur" and President of the Superior Councils of the two Islands.

On his arrival in July, 1767, at the same time as Governor Dumas, Poivre settled at Mon Plaisir, having observed that the climate of that region suited the culture of the spice and other plants imported by him from the Dutch Indies. He bestowed the greatest care on these new introductions, among which were the pepper and the cinnamon trees, some fruit trees, and others

yielding dyes and varnishes. He laid out the garden in a picturesque manner, and planted it with native, African, Indian, Malayan and Australian plants. He also made a network of irrigation canals for the proper supply of water. In 1769 Poivre sent out M. Provost, a former 'writer' of the French East India Company's fleet, on a collecting expedition, which proved very successful. In June, 1770, the two ships under his command returned with 400 nutmeg plants, 10 clove plants and a case of clove seeds.

Another expedition under Provost in June, 1771, was even more productive. In June, 1772, the ships returned with numerous nutmeg and clove plants, which were distributed in the Ile de France, Bourbon, the Seychelles and Cayenne.

Poivre owed much to the advice of Philibert de Commerson, the distinguished naturalist, who had travelled round the world with Bougainville, and who settled in the Ile de France; also to Charpentier de Cossigny, whose property, Palma, had become a veritable nursery, and who generously presented to the Botanic Garden all the varieties which had succeeded at Palma.

Many explorers and men of science visited the Island, and some of them introduced new plants, such as the Indian Almond (*Terminalia Catappa*), the mango, mulberry, allspice, ravensera, peach trees, and the sago palm, while Sonnerat, who stayed at Mon Plaisir with Poivre for some time, introduced the bread-fruit, cocoa, mangosteen, and many other fruit-bearing or resin-yielding trees.

The Pamplemousse tree was a sort of orange (*Citrus decumana*), probably brought from Java by the Dutch. Its fruit, a large orange of slightly bitter-sweet flavour was called "bambolmas" in Tamil, perverted into "pamplemousse," and gave its name to that district of the Island rendered so famous by the author of "Paul et Virginie."

Bernardin de Saint Pierre paid more than one visit to Mon Plaisir, and though he was to give up his original idea of founding on the island a Republic on the lines of More's Utopia, he was inspired by a local anecdote, combined with the beautiful natural surroundings, to write the delightful arcadian pastoral, "Paul et Virginie." To this day there is shown in the Pamplemousses Garden the so-called tomb of Paul and Virginie, which is in reality only the stone of an ancient altar to the goddess Flora, erected by Governor Barthélemy David. (Plate ix.)

Although Poivre had spent a fortune on improvements and new installation at Mon Plaisir, he handed over the property to the Government on his departure in October, 1772, for the same amount as he had spent on its purchase, and refused to accept a larger sum.

Céré.—Before his departure Poivre recommended, as his successor, his pupil and friend Jean Nicolas de Céré, who had for some time efficiently collaborated with Poivre in the work of the Garden.

Céré was a Major of Infantry, Commandant of the Pamplemousses District, Director of the Royal Gardens, Chevalier of the Legion of Honour, Corresponding member of the Philippines

1.

2.

3.

4.

Economic Society, of the Agricultural Society, and of the Natural History Museum in Paris. Born on the Ile de France in 1737, he came of an Italian family of ancient nobility, settled in France since the 14th century, his father being a naval officer commanding the harbour.

Young Céré also started his career in the Navy, and after two campaigns, settled in the Ile de France, where he had meanwhile inherited considerable property from his father. Soon after his arrival he met Poivre, who was greatly taken with the serious and high-minded young man, who showed such a pronounced taste for botany—and so the foundation for a life-long friendship and co-operation was laid.

Céré's financial independence enabled them to overcome the opposition of the "Intendant" of those days. He did not hesitate to emulate his friend and master in sacrificing his private fortune to carry out important improvements in the Garden.

The growth and flowering of the first spice plants of the Gardens were followed in France with close attention, and announced as great events.

Albert Pitot, in his "Sketches," states that the first clove flowered in 1775, and the first fruit that had set was solemnly picked by Céré in the presence of the authorities, and sent home to France by Chevalier de Ternay, as a humble gift to His Majesty. Two years later the clove bore a large crop. The nutmegs were longer in maturing. The first flower appeared in March, 1778, the first fruit being once more solemnly picked in December, and despatched to the King.

Céré's merit was recognised in spite of all opposition, and in 1775 he was appointed Director of the Royal Garden.

Here he effected great improvements, and carried out many useful works at his own expense. Pepper trees, cinnamon, cloves and nutmegs soon increased largely, and seedlings were distributed among the inhabitants of the two islands. This experiment was so successful that a few years later a private citizen reaped 28,000 cloves, and M. Hubert, at Bourbon, had in 1782, a plantation of 8000 clove shrubs.

M. Céré extended his patriotic benefactions even further, sending cases of plants from his nurseries to the French Colonies of America.

The traveller Melon, who landed on the Island in 1786, after visiting Europe, Egypt and Asia, recorded his impressions of Mon Plaisir as one of the marvels of the world, the climate of the Island permitting the culture of the products of all parts of the globe. There were over 6000 kinds of trees and shrubs from different continents, some of which plants had not yet reached perfection.

Hospitality was extended by Céré to many well-known men, such as Suffren, d'Entrecasteaux, Booz, Commerson, Stadtmann, and others, who came to him with introductions. Among them was the botanist Du Petit-Thouars, whose brother commanded the vessel sent to find Lapérouse, and who, on his arrival at the Island in 1793, learnt that the vessel had been lost with all his private fortune. Céré proved his sympathy in keeping M. Du

Petit-Thouars as his guest for 18 months, and spared no delicate attention to make him feel at home.

Auguste Céré.—Céré having died in 1810, he was succeeded by his son Auguste, as Director of the Pamplemousses Garden.

Auguste Céré continued the excellent traditions he had inherited from his father, until on December 3rd, 1810, the Island was surrendered to Great Britain, and General Darling abolished the Communal Councils of which Céré was a member, as Commandant of Pamplemousses, thus depriving him of his post.

White and Burke.—His successor, White, had but a meagre knowledge of horticulture, agriculture or botany, and in order to hide his ignorance, an honorary Supervisorship was created, the chief of the Island Medical Service, Burke, being appointed to it. But owing to White's carelessness weeds soon gained ground and choked many of the rare exotic plants obtained with so much labour and expense.

Newman and Charles Telfair.—The Garden was falling into sad neglect, when, in 1826, Newman was appointed to succeed White; he was warmly recommended by Lord Bathurst. Charles Telfair replaced Burke, and stimulated Newman to activity; he rescued the Garden to a certain extent from its derelict condition, adding some new species, and replacing others which had been destroyed. Telfair, however, allowed himself to be distracted from his public work by devoting much time and care to his own property, "Bois Chéri," where, with the aid of the botanist Bojer, he was naturalising plants with a zeal equal to that of Poivre and Nicholas Céré.

His post was abolished in 1829, and Newman had the whole administration of the Garden. Matters moved very slowly, and appeals to the Natural History Society, etc., remained unanswered, when at last, moved by warnings from many quarters, Sir William Hooker, Director of the Royal Gardens, Kew, persuaded Earl Grey, then Colonial Secretary, to authorise the Government of the Island in 1848, to raise the funds necessary for the restoration of the Garden.

James Duncan.—This arduous task was confided to James Duncan, who was appointed Director of the Garden in May, 1849, and occupied the post for 15 years with great success.

He surrounded the Garden with an impenetrable hedge of Madagascar plum (*Flacourtia Ramontchi*), and introduced many rare and beautiful trees and shrubs. Some idea of his activities may be gained from his "Catalogue of Plants in the Royal Botanic Garden of Mauritius," published in 1863.

A violent cyclone raging for a week in February, 1861, destroyed numerous valuable plants. Duncan kept up the traditions of the Garden, and in the year 1862 alone, 25,925 plants were distributed by him to the inhabitants.

Dr. Charles Meller.—Duncan's successor in 1866, Dr. Charles Meller, was sent to Australia and New Caledonia to obtain new

varieties of sugar cane, as the canes on the Island had been ravaged by disease. Meller sent several kinds to Mauritius and saved its agriculture from imminent ruin. He died in New South Wales.

John Horne, who had been temporary Director after Duncan's departure, as well as Assistant Director under Dr. Meller, became temporary Director after the latter's death in 1866, was appointed Director in August, 1876. He was sent to Fiji in 1877 to procure new canes, which proved of great value.

William Scott.—From February, 1881, William Scott was Horne's assistant, and succeeded him as Director in August, 1893. General Gordon stayed with him for some weeks when he visited the Island. Scott was a very able Director, and his annual reports show the extent of the works and improvements carried out under his régime. His activities were sadly hampered by the hurricane of April 29th, 1892, which destroyed a great many valuable specimens, though by dint of great care and patience he succeeded in saving a certain number, so that the Gardens soon resumed their normal appearance.

Just as the Gardens were recovering, on December 5th, a cyclone, the centre of which was about four miles to the east of the Island, wrought great havoc among the buildings and gardens of the establishment. The orchid houses and pavilions were wrecked, and many palms and other trees uprooted and broken.

The big *Lodoicea Sechellarum* was stripped of its leaves and nearly died, the lakes were choked with fallen trees and branches. Once more great efforts were needed to repair the damage.

In the year 1897 also, there was an exceptional drought, which caused great damage. The lakes in the Gardens were almost entirely dry, and great efforts were needed to keep the plants alive.

Joseph Vankeirsbilck. Paul Koenig.—After Scott's departure Joseph Vankeirsbilck was appointed Director of the Gardens in July, 1898; he occupied this post until his death in September, 1903.

After his death in 1903, Paul Koenig took over the post of Director. His first annual report gives an interesting description of the varieties of palms growing in the Gardens.

The 1905 report gives a good idea of the progress made since the publication of Duncan's Catalogue:

Duncan had distributed 25,925 plants among the Islanders in 1862, while in 1905, 317,291 plants from the Gardens were sold, given away or exchanged at home and abroad. The swamp of Mon Plaisir was drained, and after an unsuccessful experiment of planting it with Lichis, it was turned in part into a rice field (where 16 varieties from Madagascar, Ceylon and British Guiana were very successfully grown), and partly planted with lime trees raised from garden seedlings.

In 1909 Java tobacco seeds were sold or given away to the

Islanders, and new kinds of sugar canes were received from Queensland and the West Indies.

While cocoa and some rubber trees from Madagascar had hitherto given very poor results, mandioca and coffee were growing very satisfactorily in 1912.

On the creation of an Agricultural Department the Pamplemousses Botanic Garden passed under the administration of the Director of that Department in July, 1913.

The new Director created a section for economic plants, which soon had to be enlarged to its present extent of 10 arpents.

In 1912 and 1913 it was found that the ornamental plants and trees had been sadly neglected, and much labour was needed to reduce their too luxuriant growth. Many fresh specimens of flowers and plants were grown, and the Gardens were replanted section by section.

A marble tablet was also put up in the Duchess of York Square to commemorate the planting of two Norfolk Island Pines (*Araucaria excelsa*) by Queen Mary in August, 1901.

The 1914 report shows the considerable development of the experimental cultivation and scientific study of the sugar cane, but cotton has given purely negative results, owing to the ravages of *Tortrix insulana* and other pests.

The Public Works Department have restored the buildings, and are keeping the roads and paths in excellent condition.

The exchange of plants and seeds with other countries has grown enormously. But it is chiefly in the study and cultivation of the sugar cane and the scientific application of manures increasing its productivity, that the Pamplemousses Garden is rendering such valuable services to the Empire. It may well be said that to-day it has attained the high-water mark of its usefulness in this respect.

EXPLANATION OF PLATES IX. & X.

1. The "Tomb" of Paul and Virginie, with a plant of *Encephalartos Hildebrandtii* on either side.
2. Avenue of the "Tomb" of Paul and Virginie, Pamplemousses.
3. Lake in the Botanic Garden.
4. A corner of the Botanic Garden, with Sabal Palms and *Areca Catechu* in the centre.

XX.—MISCELLANEOUS NOTES.

Botanical Magazine.—The following plants are figured in the number for April, May and June:—*Liparis macrantha*, Rolfe (t. 8797), from the Island of Formosa; *Malus rivularis*, Roemer (t. 8798), a native of Western North America; *Wittia panamensis*, Britton & Rose (t. 8799), from the mountains of Panama; *Lonicera similis*, Hemsl. var. *Delavayi*, Rehder (t. 8800), from South-Western China; *Primula bellidifolia*, King ex Hook. f. (t. 8801), a native of the Eastern Himalaya; *Rhododendron*

oleifolium, Franch. (t. 8802), from the mountains of Yunnan; *Calanthe tricarinata*, Lindl. (t. 8803), from Northern India, Yunnan and Japan; *Lonicera chaetocarpa*, Rehder (t. 8804), a native of Western China; *Desmodium cinerascens*, Franch. (t. 8805), also from Western China; *Ipomoea Pes. Tigridis*, Linn. var. longibracteata, Vatke (t. 8806), a native of Eastern Tropical Africa, and *Disporum pullum*, Salisb. var. *brunnea*, C. H. Wright (t. 8807), a native of Western Hupeh, China.

Forest Law in America.*—In this work the development of forest law in North America is discussed so far as it affects forest fires, the preservation of existing forest resources, the reafforestation of cut-over or burned-over land, the extension of forest areas, and the systematic management of forests for productive purposes, from its inception in the seventeenth century to the close of 1916. The book consists of 254 pages of letterpress, exclusive of introductory matter and an ample index, and is divided into seven chapters which are sub-divided in order that the various laws as they affect different States may be conveniently handled. Almost from the earliest days of the occupation of America by Europeans, individuals appear to have interested themselves in forestry matters and numerous laws were passed by different States in the seventeenth and eighteenth centuries concerning the indiscreet cutting of timber and fire protection. These laws, however, had no very far-reaching effect, and although a general forest policy was urged upon several occasions it was not until 1885 that the first comprehensive forest administration Act was passed. This Act was the result of the deliberations of a committee of experts appointed by the comptroller of New York in 1884 to investigate and report upon a system of forest preservation suitable for adoption by the State. It carried an appropriation of 15,000 dollars for the expenses of the first year, and provided for a permanent forest commission of three members, a state warden, state inspectors and other necessary agents; created a forest reserve to consist of all lands then owned or thereafter to be acquired by the state in eleven counties in the Adirondack region and three counties in the Catskill Mountains, and declared that the lands comprising the reserve should be for ever kept as wild forest lands in the full control of the State and not be sold, leased, or taken by public or private corporations. Full provision was made for the prevention and control of forest fires; railroad companies were required to clear rights of way of inflammable material in forest or other land particularly subject to fire, to equip locomotives with proper appliances for the prevention of fires, and to employ patrolmen in dangerous periods. From 1885 onward Acts and amendments appear to have been passed with bewildering frequency and Mr. Kinney has done good work by summarising

* The Development of Forest Law in America, by J. P. Kinney, A.B., LL.B., M.F., Chief Supervisor of Forests, United States Indian Service, New York: John Wiley & Sons, Inc. London: Messrs. Chapman & Hall, 11, Henrietta Street, Covent Garden, W.C. 2. Price 11s. 6d. net.

them in a concise form in his present book. Some idea of the work entailed in the compilation of the book may be gathered from the number of footnotes given in reference to the different Acts. W. D.

The Essentials of American Timber Law.*—This is a companion volume to "The Development of Forest Law in America," by the same author, published in 1917. It deals with American Law in relation to property under its various classifications, the forms of private possession of land, trees and timber as property, the liability of tenants regarding timber, waste as applied to timber, remedies for waste, civil liability for trespass upon timber, and for the conversion of timber products, statutory civil liability for timber trespass, injuries to growing trees as a criminal offence, contracts regarding growing timber, contracts regarding the preparation and manufacture of timber products, contracts for the sale of timber products, the inspection and measurement of timber products, the transportation of timber products by flotation, standing timber as included in a mortgage, trees on a boundary line or in a highway, trees nursery equipment, and sawmills, as fixtures, and the policy of the national government in regard to the free use of timber taken from public lands. The main object of the work is to place before landowners, foresters, and lumbermen a concise summary of American Law as it affects their interests as interpreted by legal decisions. When possible it is compared with British Law upon similar subjects. The book represents a great amount of work, for the matter has had to be sought for in many places, as is instanced by the numerous footnotes referring to cases that have been decided in North American and British Courts of Justice. W. D.

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* The Essentials of American Timber Law. By J. P. Kinney, A.B., LL.B., M.F. New York, John Wiley & Son, Ltd.; London, Chapman and Hall, Ltd. (1917), price 13s. 6d. net.

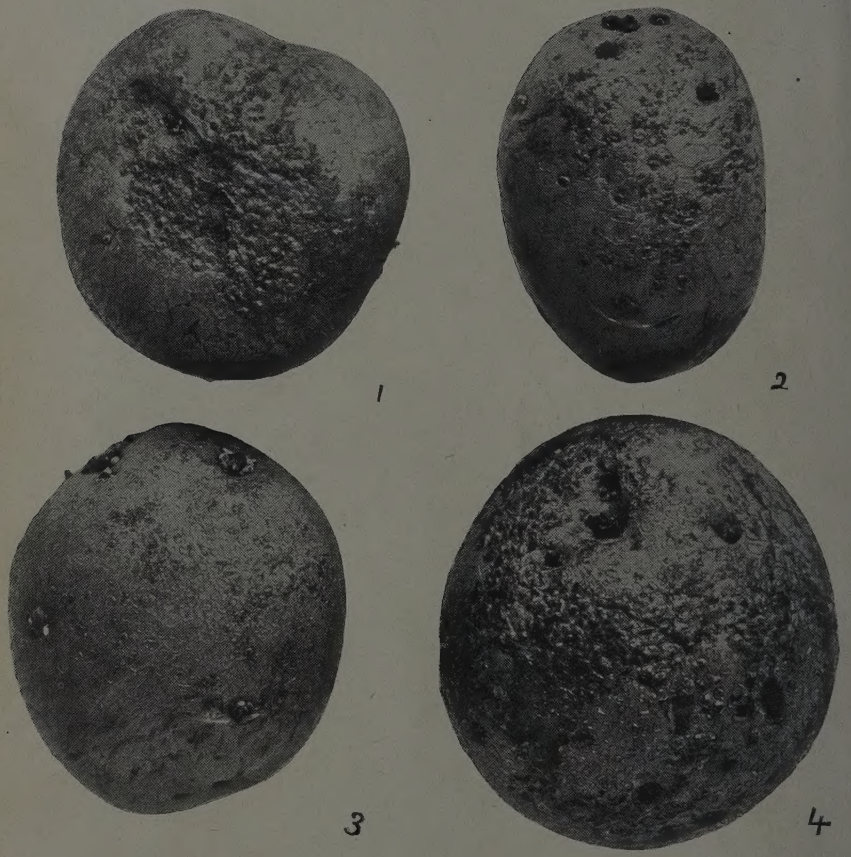

Plate XI.—Potato tubers affected with Skin Spot. 1, 3, 4. Arran Chief. 2. British Queen.